

A close-up photograph of a horse's eye, showing the brown iris, dark eyelashes, and the surrounding brown skin and white hair of the mane.

2b

HAVO | VWO

your biology

TEXTBOOK

your biology

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your biology
TEXTBOOK

your biology

BIOLOGIE VOOR TWEETALIG ONDERWIJS
HAVO|VWO ONDERBOUW

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Introduction

This biology book is part 2b of *Your Biology*. Browsing through the book will show you exactly how it is structured. The way we wrote this book will let you work with it on your own.

You can also ask your teacher for help if you need it.

There is a workbook that belongs with this book, as well as an answer book and the Your Biology website. The website has a digital version of the workbook and/or textbook. There is also the possibility of practising with digital material (including the diagnostic tests).

WORKING WITH YOUR BIOLOGY

The topics in this book are called units. Each unit starts off with an introduction. This gives a brief description of what you can expect in the unit. Each unit is made up of the following sections:

- Basics
- Extra
- Summary
- Diagnostic test
- Extension

We will now describe how to work with each of these sections.

BASICS

The Basics contain texts and figures that you are going to read. You will come across references to the exercises that are in the workbook, For example:

WB EXERCISE 1, PAGE 6

You should do the exercises in your workbook.

There is sometimes an optional exercise at the end of the Basics. Your teacher will tell you whether you have to do the optional exercise.

When you have finished the exercises, you will find a reference back to the textbook, For example:

TB BASICS 2, PAGE 12

Sometimes you will have to use the Internet for an exercise.

There are also some exercises that you need a worksheet for. The worksheets are in the workbook. It is useful if you have a pair of scissors and a glue stick. As well as the pens you normally write with, you will need a drawing pencil (HB) and coloured pencils. You can use the answer book to check the exercises yourself.

EXTRA

At the end of the Basics, you will find the Extra section. Once you have finished the Basics, your teacher will tell you whether you have to do the Extra. The completed exercises from the Extra section can be checked with the answer book.

SUMMARY

The summary gives a brief description of what you have learned in the basics and (if you did it) the extra section. This is what you will have to 'know and do' for a test.

DIAGNOSTIC TEST

The diagnostic test lets you see whether you know and can do everything that is in the summary. You can check the diagnostic test using the answer book.

You can also do the diagnostic test via the methods site. You can then see straight away whether your answers are correct.

EXTENSION

If you know and can do everything that is in the summary, you can start on the Extension. This is additional material, with different sections that you can choose between. You do not have to do all the sections; your teacher will tell you how many you have to choose. The exercises in the Extension can also be checked using the answer book.

We hope that you will enjoy working with this book.

The authors

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Inheritance and evolution



BASICS

- 1 Genotype and phenotype
- 2 Chromosomes, genes and proteins
- 3 Sexual reproduction
- 4 Mutations
- 5 The theory of evolution
- 6 Arguments for the theory of evolution
- 7 The history of life on Earth
- 8 Biotechnology

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EXTRA

- 9 Dominant and recessive alleles
- 10 Genetic testing

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SUMMARY AND DIAGNOSTIC TEST

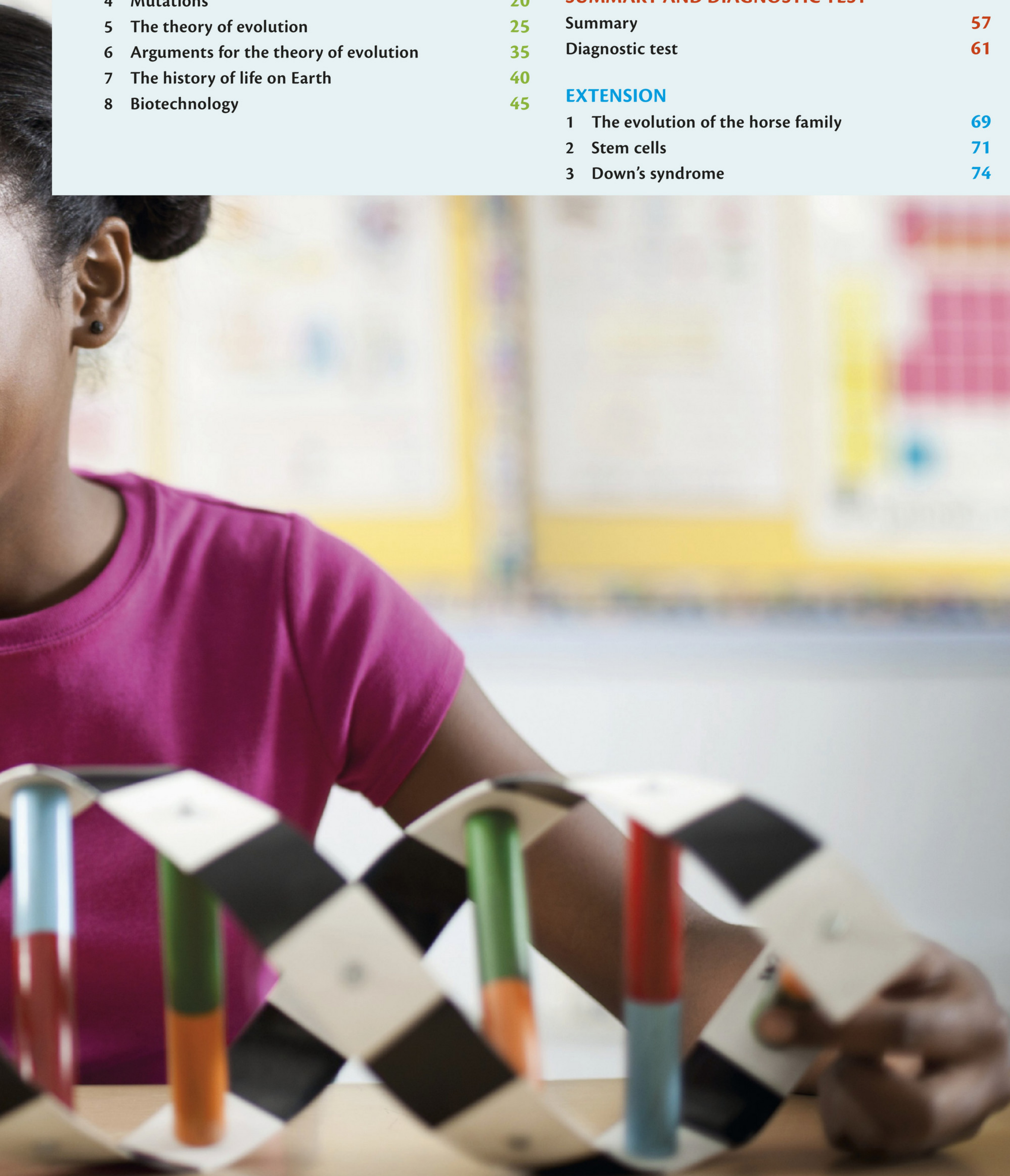
- Summary
Diagnostic test

57
61

EXTENSION

- 1 The evolution of the horse family
- 2 Stem cells
- 3 Down's syndrome

69
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This unit is called 'Inheritance and evolution'. You have inherited characteristics from your parents, just like everyone else. This unit explains how parents can pass on characteristics to their offspring.

Until the nineteenth century, people thought that all species of organisms had always existed unchanged. Today, most people have a different opinion. The species that live on Earth now originated from other species over the course of millions of years. This unit explains how this happened.

When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

1 Genotype and phenotype

People talking about a new-born baby will sometimes say, "I think he looks just like his mother" or "She has her father's eyes." You can see from the child that it has inherited characteristics from its mother and father. The appearance (the visible characteristics) of an organism is called the **phenotype** of that organism.

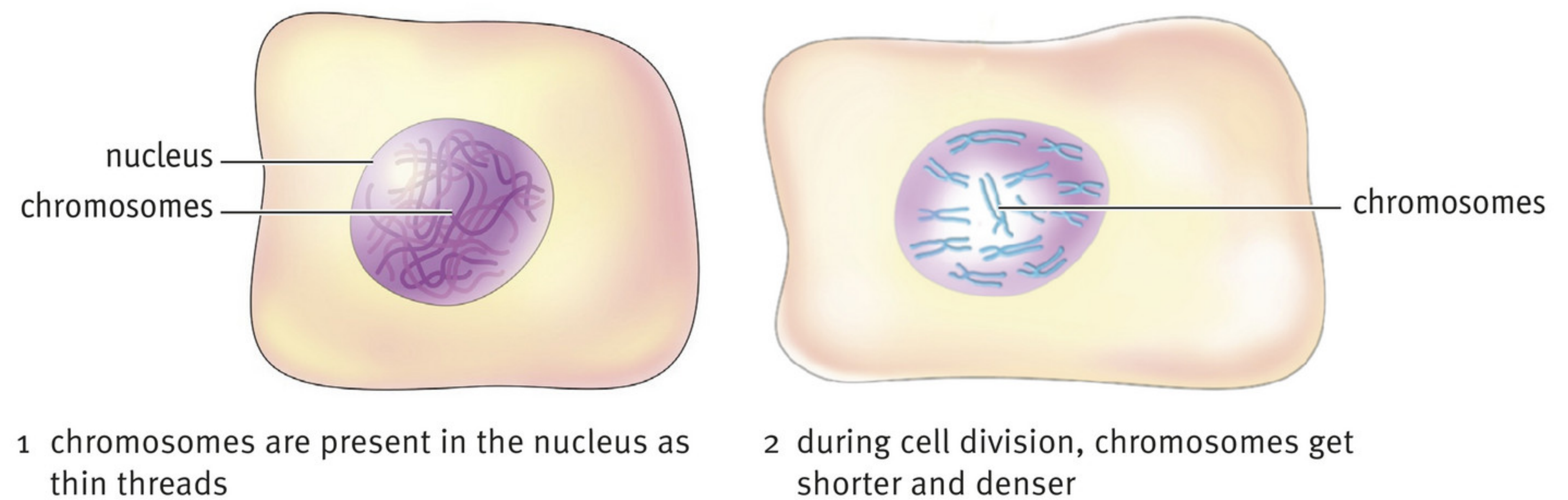
Your phenotype consists of thousands of characteristics. You have inherited many of these characteristics from your parents (for example: the colour of your hair, the colour of your eyes and the shape of your face). The **information** for your hereditary characteristics is in the DNA in the cell nuclei. News reports regularly mention DNA (see figure 1).

▼ Fig. 1

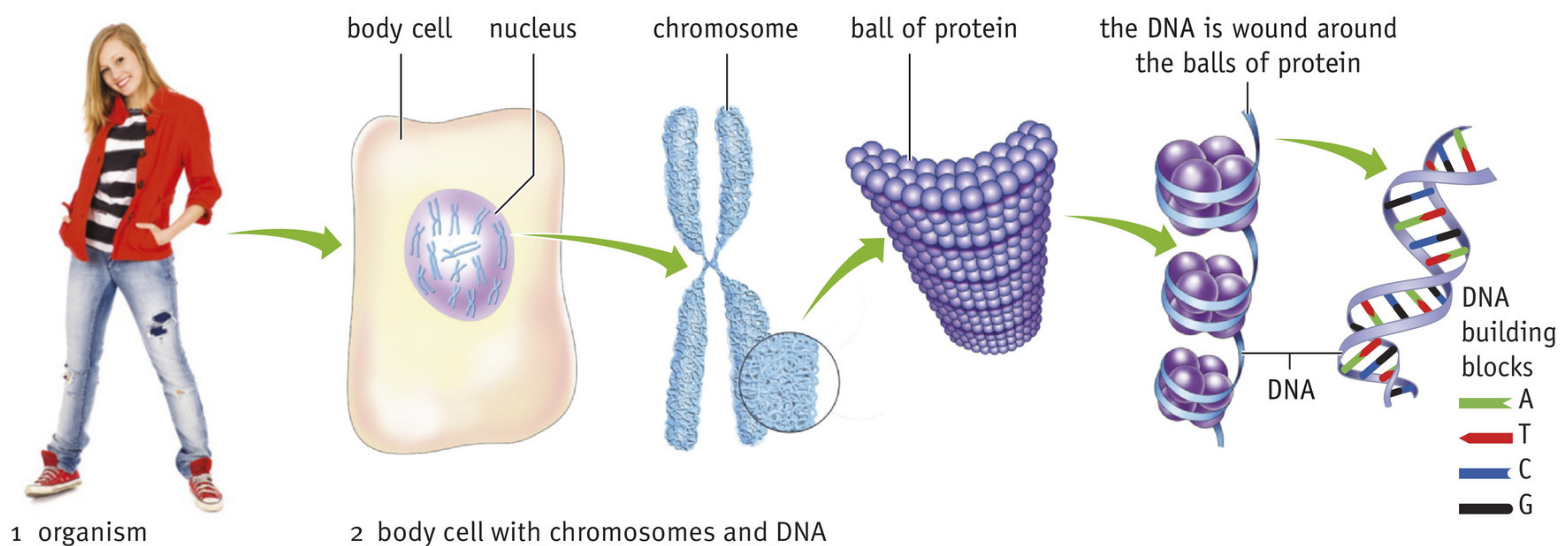


In each and every cell of your body, the nucleus contains the information for all your hereditary characteristics. Every cell nucleus in your body contains **chromosomes**. Chromosomes are elongated thin 'threads' that are all tangled together in the nucleus. The chromosomes only get shorter and thicker when a cell divides (see figure 2). The chromosomes can then be seen through a microscope. Chromosomes consist largely of the substance **DNA** (see figure 3). This substance contains the information for all your hereditary characteristics.

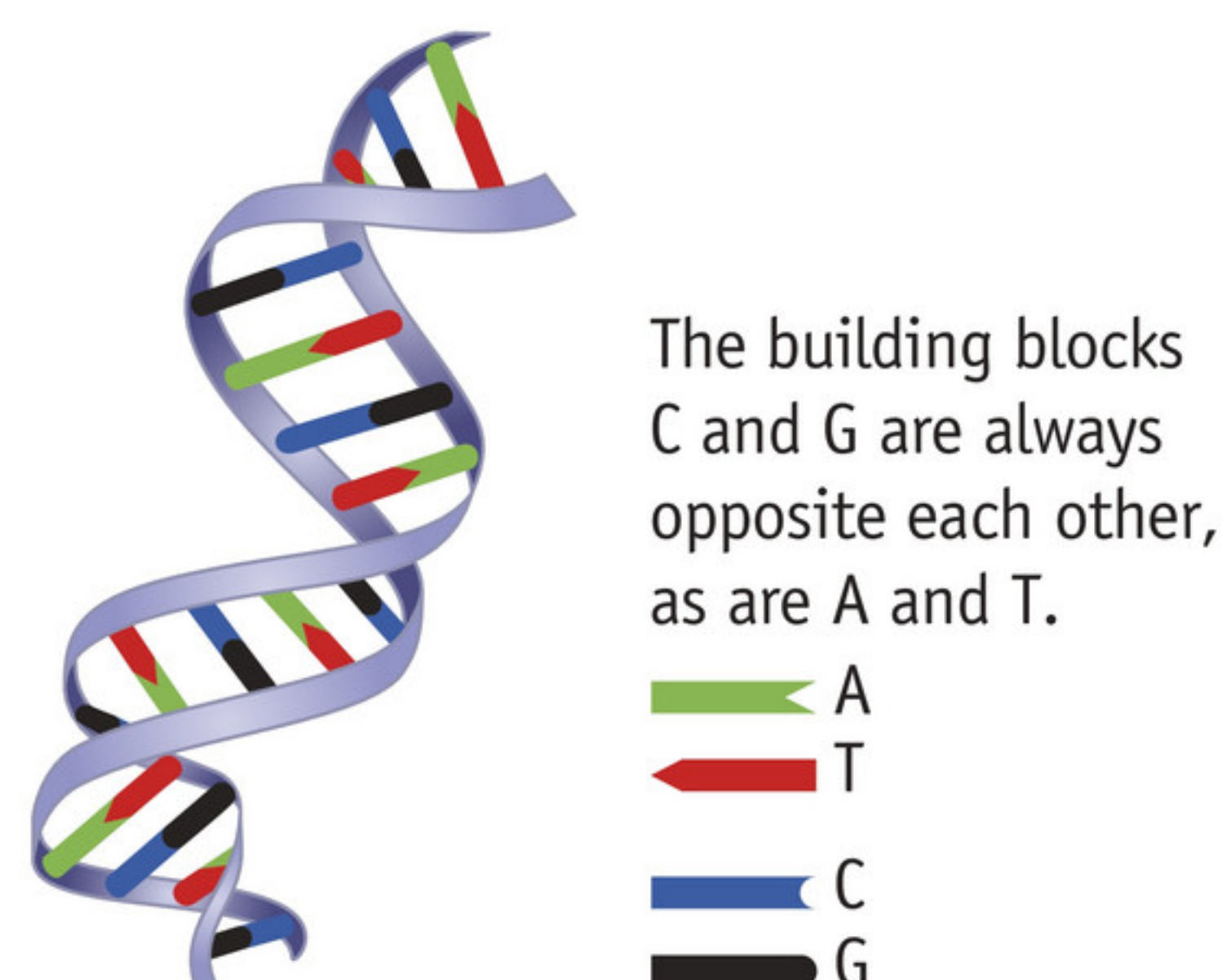
▼ **Fig. 2** A cell with a nucleus, chromosomes and DNA.



▼ **Fig. 3**



▼ **Fig. 4**

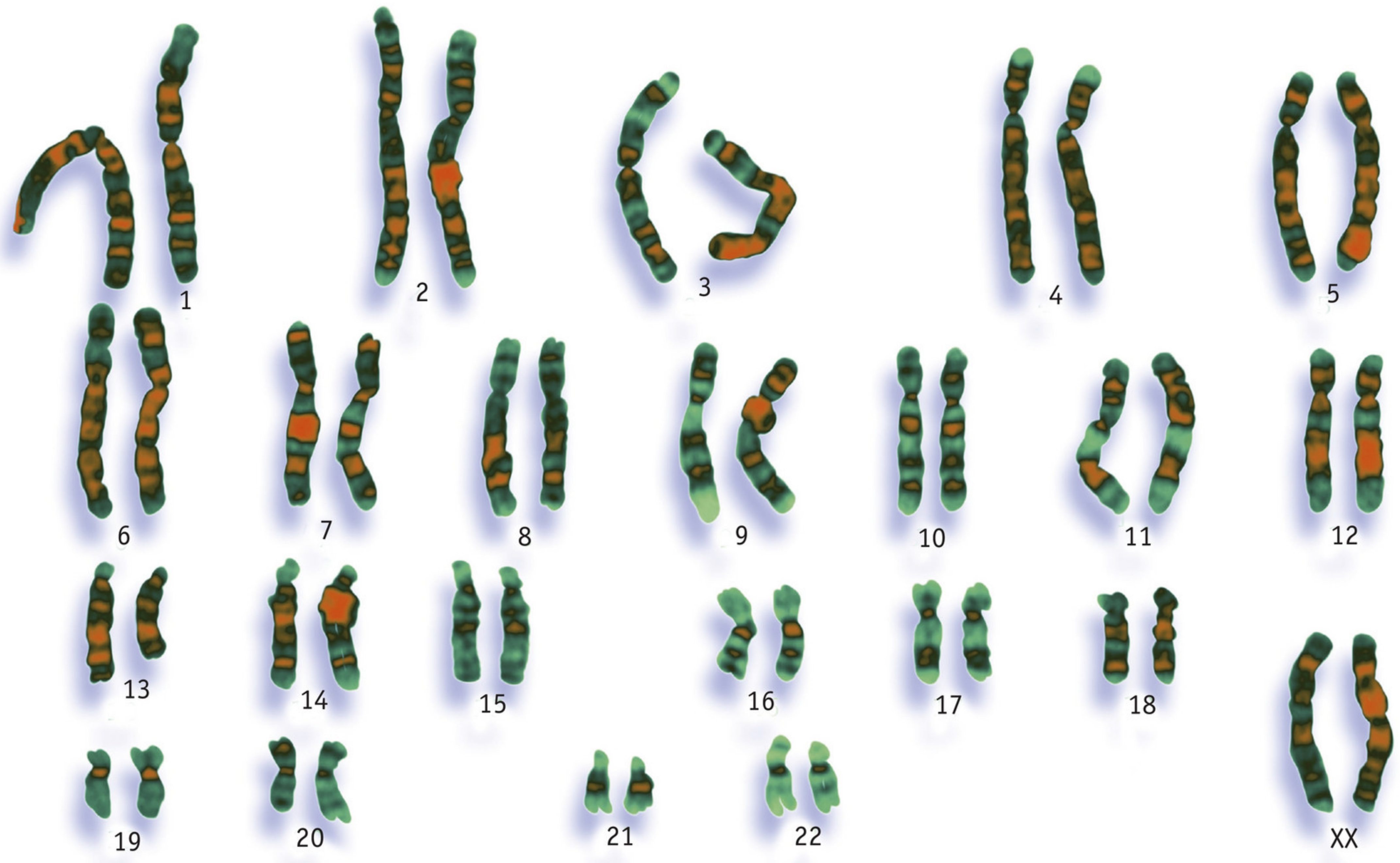


The building blocks A, T, C and G form codes with the information for hereditary characteristics.

In part 1 you learned that DNA is made up of four different building blocks: C, G, A and T. The building blocks C and G are always opposite each other, as are the building blocks A and T. Because these four DNA building blocks are in a specific order, this creates a **code** with the information for a particular hereditary characteristic (see figure 4). DNA contains a lot of different codes with the information for many different hereditary characteristics. The DNA in the chromosomes in a single cell nucleus contains all the information for all your hereditary characteristics. We call this information the **genotype**.

Figure 5 shows the chromosomes of a single cell of a woman, ordered by size and shape. This figure shows you that a human cell contains 46 chromosomes. Matching chromosomes can always be arranged two by two, so chromosomes therefore always occur in **pairs**. The two chromosomes in a pair match. They also contain information for the same hereditary characteristics.

▼ **Fig. 5** The chromosomes of a woman, arranged in pairs.



▼ **Table 1** Various species and the number of chromosomes in every body cell.

Species	Number of chromosomes
Fruit fly	8
Housefly	12
Pea	14
Onion	16
Tomato	24
Green frog	26
Cat	38
Human	46
Field mouse	46
Potato	78
Dog	78
Bracken fern	104
Hermit crab	254

The nucleus of a human cell has 23 pairs of chromosomes. This is true for all the cells that make up the body of a human. We call these the **body cells**. Some examples of body cells are liver cells, muscle cells and skin cells. Each species of organism has a fixed number of chromosomes in the nuclei of all its body cells. These chromosomes are therefore always in pairs. Table 1 shows the number of chromosomes in every body cell for a number of species. The table shows that each species has an even number of chromosomes in the body cells.

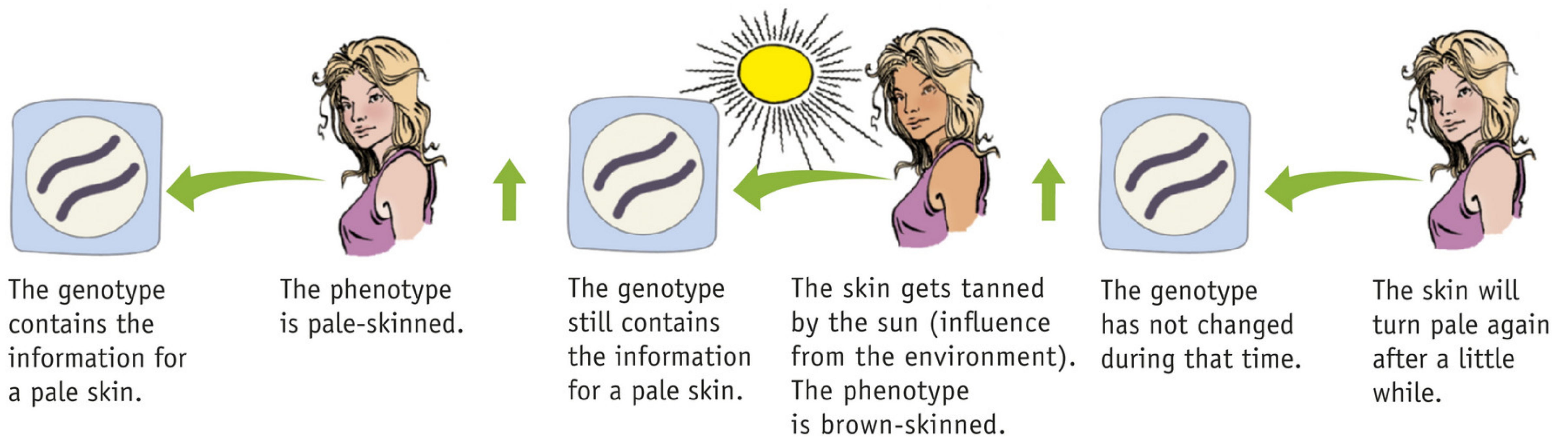
WB EXERCISE 1, PAGE 6

HOW IS THE PHENOTYPE DETERMINED?

The genotype can determine a lot of characteristics, for example whether you have black hair: the colour is determined by your genotype. If you have straight hair rather than curly hair, this characteristic is also determined by your genotype.

But the genotype does not determine all your characteristics. If you have pale skin, you may get a tan in the summer. Your phenotype changes. But in your chromosomes, you will still have the hereditary characteristics for a pale skin (see figure 6).

▼ **Fig. 6** The phenotype is the result of both the genotype and influences from the environment.



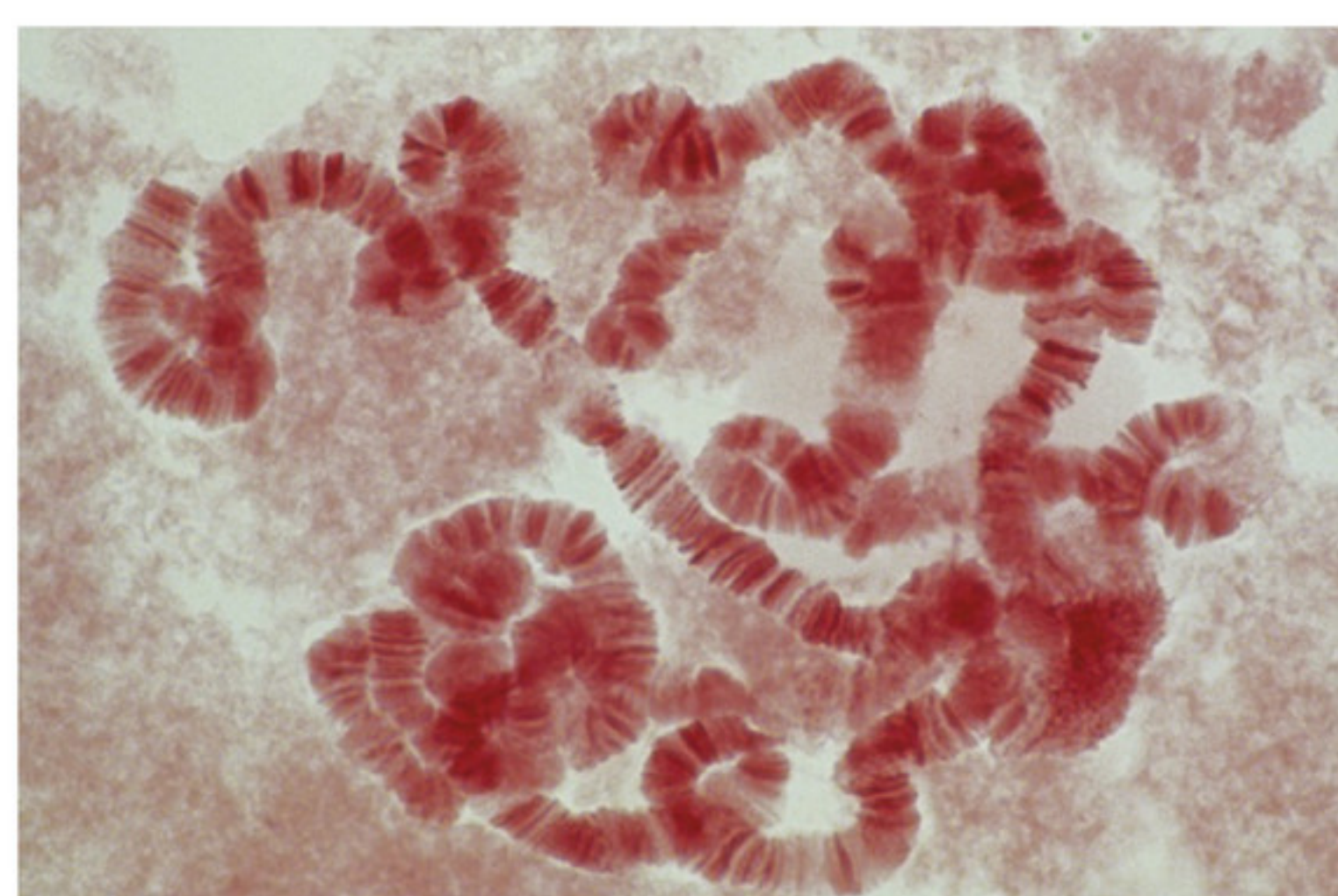
This example shows that the genotype only determines part of the phenotype. The phenotype can change for all kinds of reasons, but that still does not change the genotype. The reasons for these changes can be summarised as 'environmental influences'.

The phenotype of an organism is created by the genotype and by environmental influences.

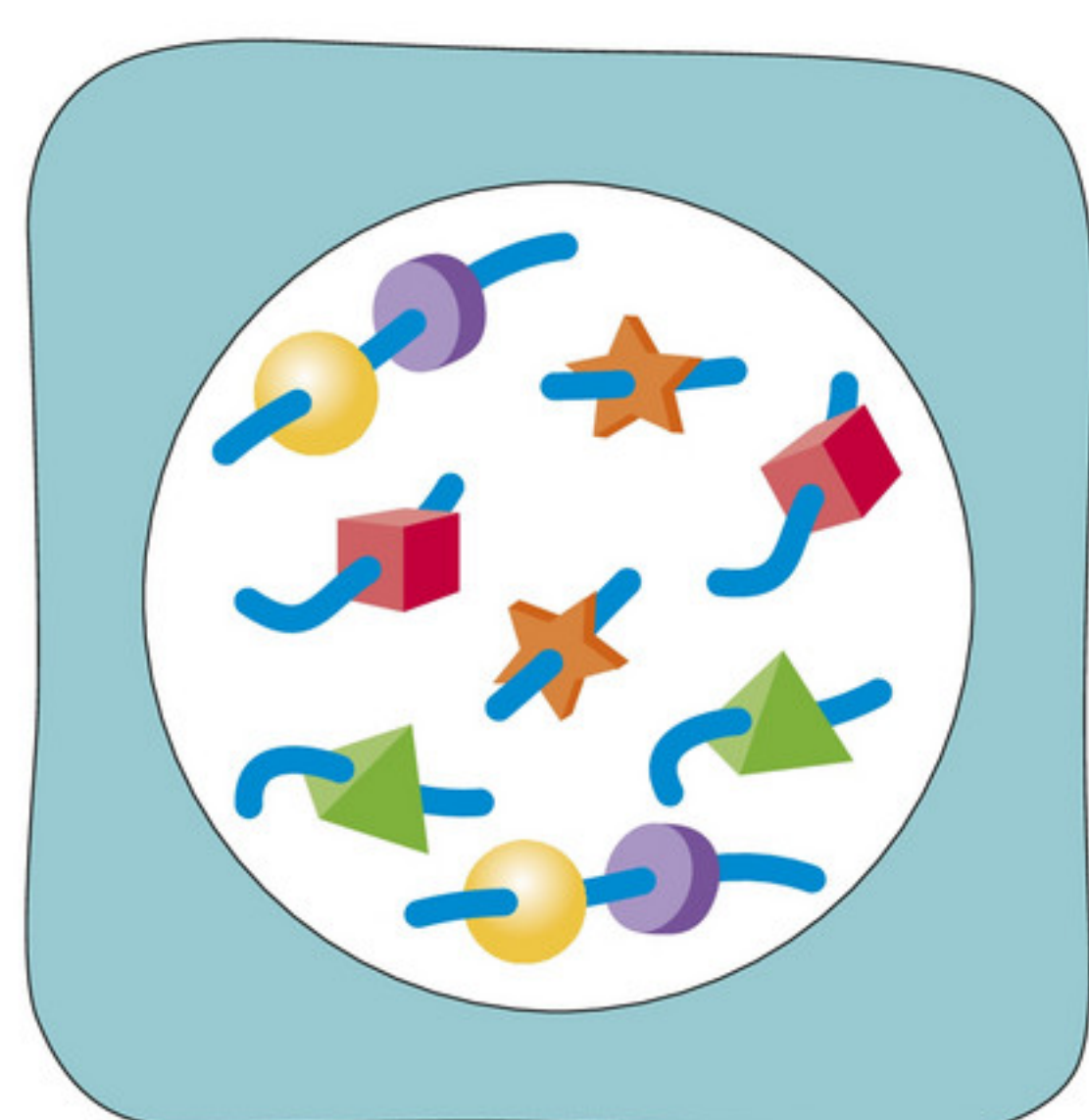
WB EXERCISES 2 AND 3, PAGE 8

2 Chromosomes, genes and proteins

▼ **Fig. 7** Chromosome (microscope photo).



▼ **Fig. 8** Body cell with chromosomes and allele pairs (schematic).



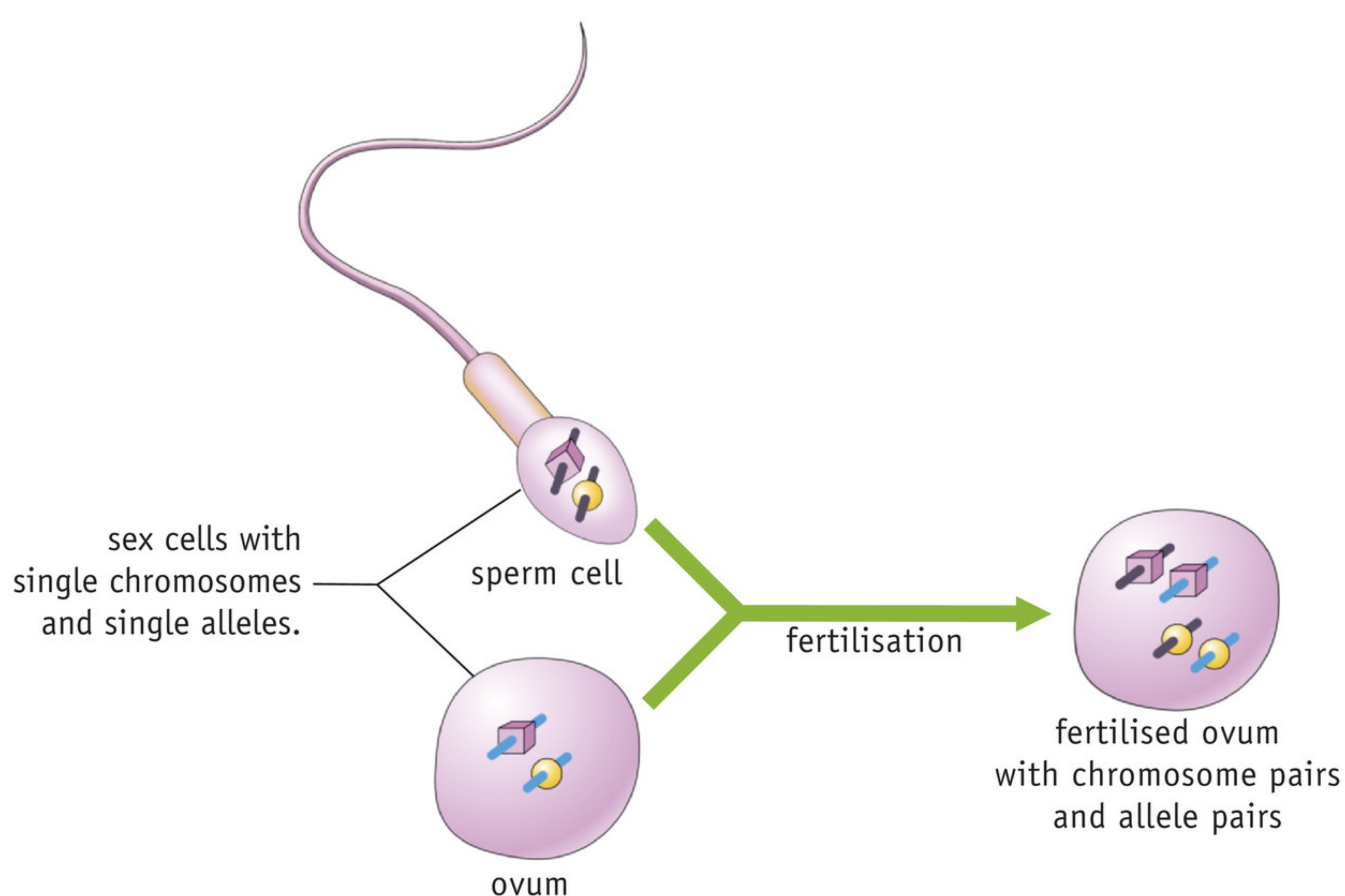
● ● ■ ▲ ★ = alleles

Every human has thousands of hereditary characteristics. The information for all of them can be found in just 46 chromosomes. Each chromosome therefore contains the information for a large number of hereditary characteristics. A **gene** is a part of a chromosome that contains the information for one hereditary characteristic. Each chromosome contains lots of genes. The genotype is the sum total of the genes in a cell nucleus. Each cell that has a nucleus contains all the genes.

You have learned that the chromosomes are found in pairs in body cells. The two chromosomes in a pair match. They therefore contain genes for the same hereditary characteristics (see figure 8). The genes are therefore always in pairs in the body cells. A single copy of a pair of genes is called an **allele**; a pair of genes is called an **allele pair**. One allele pair contains the information for a single hereditary characteristic – the colour of your eyes, for example. However, the alleles of an allele pair can contain different types of information, for example one allele with information for blue eyes and one allele for a brown eye colour. You will learn more about that in Basics 3.

The nuclei of **sex cells** (ova and sperm cells) also contain chromosomes. However, the chromosomes do not occur in pairs in sex cells, but are instead **single** copies. A human sex cell therefore does not contain 46 chromosomes, but instead has only 23. That is why a sex cell has *no* allele pairs, but just single alleles.

▼ **Fig. 9** Chromosomes during fertilisation.



The nuclei of a sperm cell and ovum fuse together during fertilisation. The chromosomes of the sperm cell and the chromosomes of the ovum then come together in the nucleus of the fertilised ovum.

The nucleus of the sperm cell contains 23 chromosomes from the father. The nucleus of the ovum contains 23 chromosomes from the mother. The nucleus of the fertilised egg cell contains 46 chromosomes that are in pairs. One chromosome in each pair comes from the mother and one from the father (see figure 9). One allele of each allele pair therefore comes from the father and one allele from the mother. A DNA kinship test uses this information (see figure 10).

▼ Fig. 10

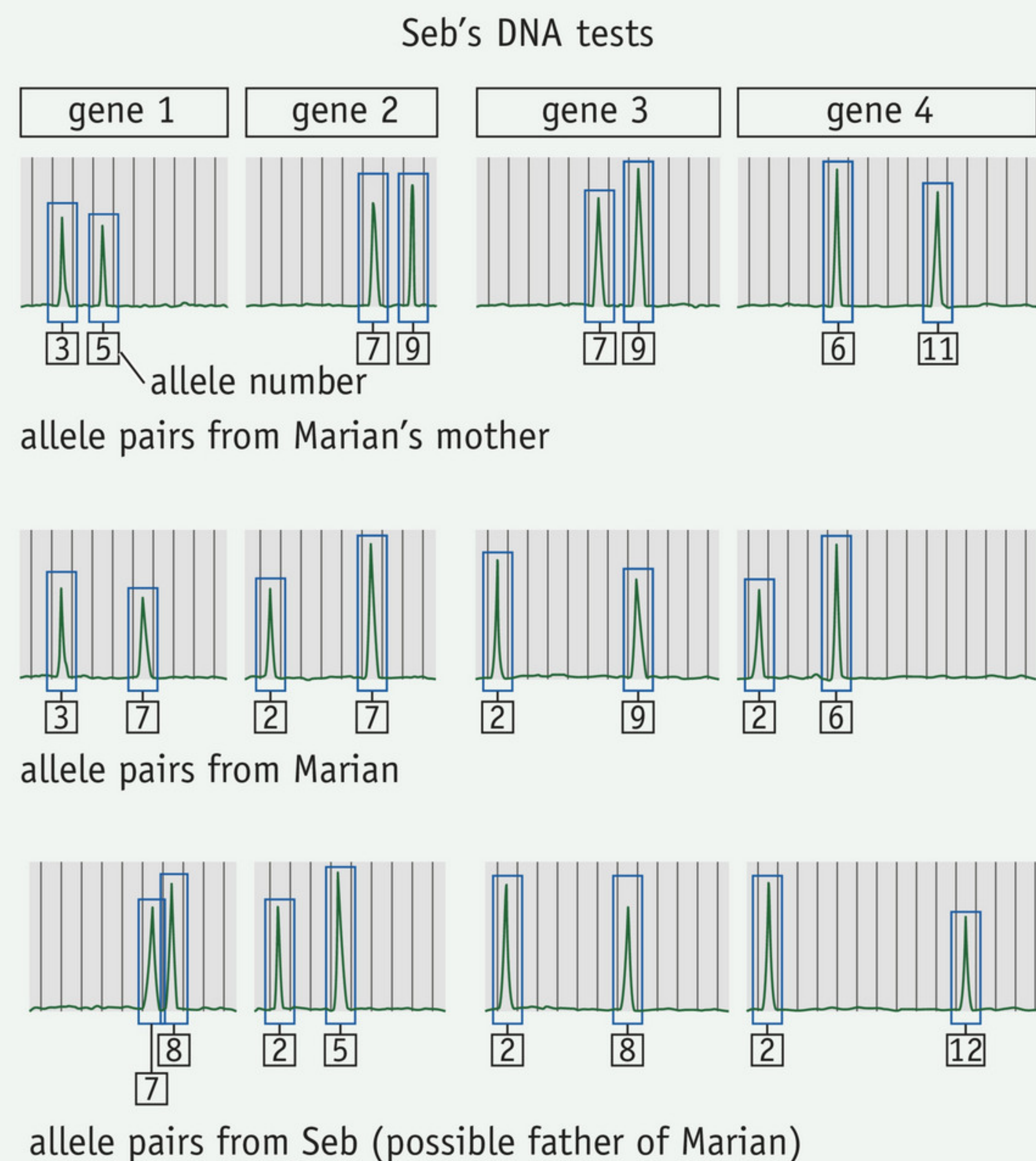
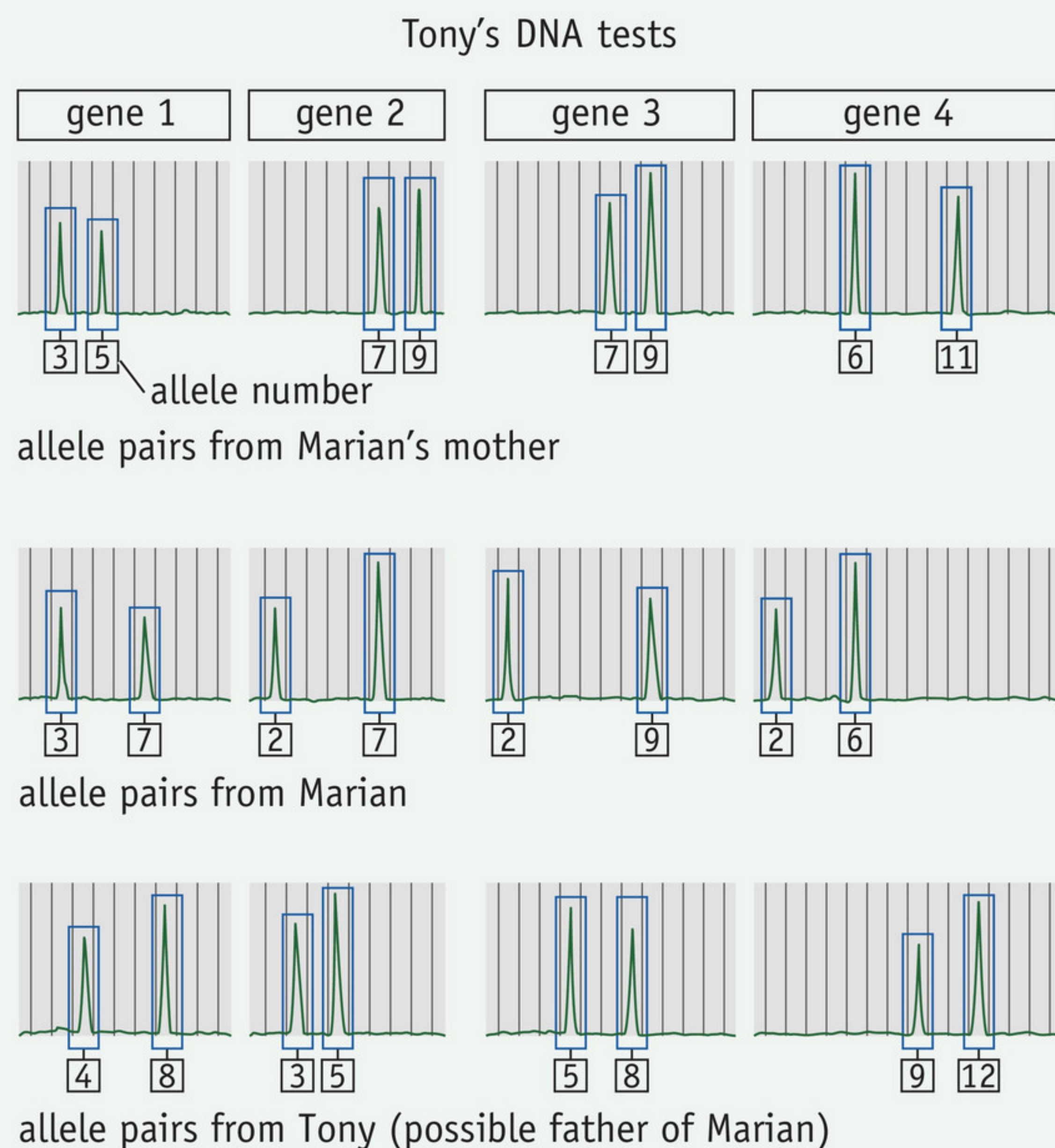
DNA kinship test

Every human has one half their alleles from their father and one half of their alleles from their mother. It is therefore possible to use a DNA kinship test to determine whether a man is the biological father of a child (see the figures).

The child, Marian, wants to have two possible fathers tested, Tony and Seb. The alleles of Marian's mother are known. If Marian has alleles that are not from the mother and not from the potential father who is being

tested, then that man is not the child's biological father.

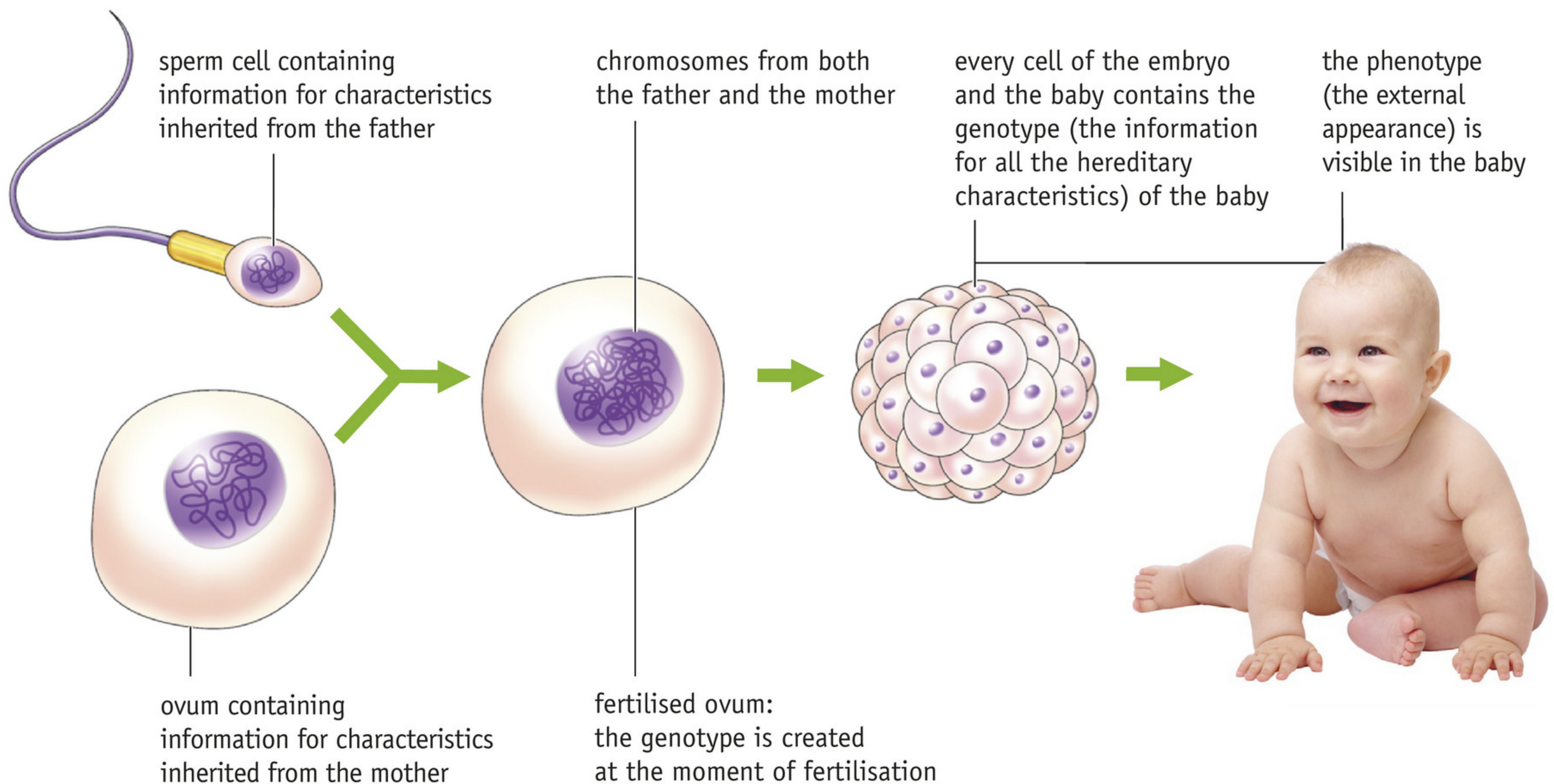
Four different genes (four allele pairs) were examined in this test. These are genes that have a lot of different alleles. In this case, the alleles have been numbered. If a man has the same four allele numbers as Marian, then this man is extremely likely to be Marian's father.



When the chromosomes of the sperm cell and the chromosomes of the ovum have come together, the fertilised egg cell contains pairs of chromosomes and pairs of alleles. The information for all the hereditary characteristics of the new organism is then complete.

The genotype of an organism is created at the moment of fertilisation (see figure 11).

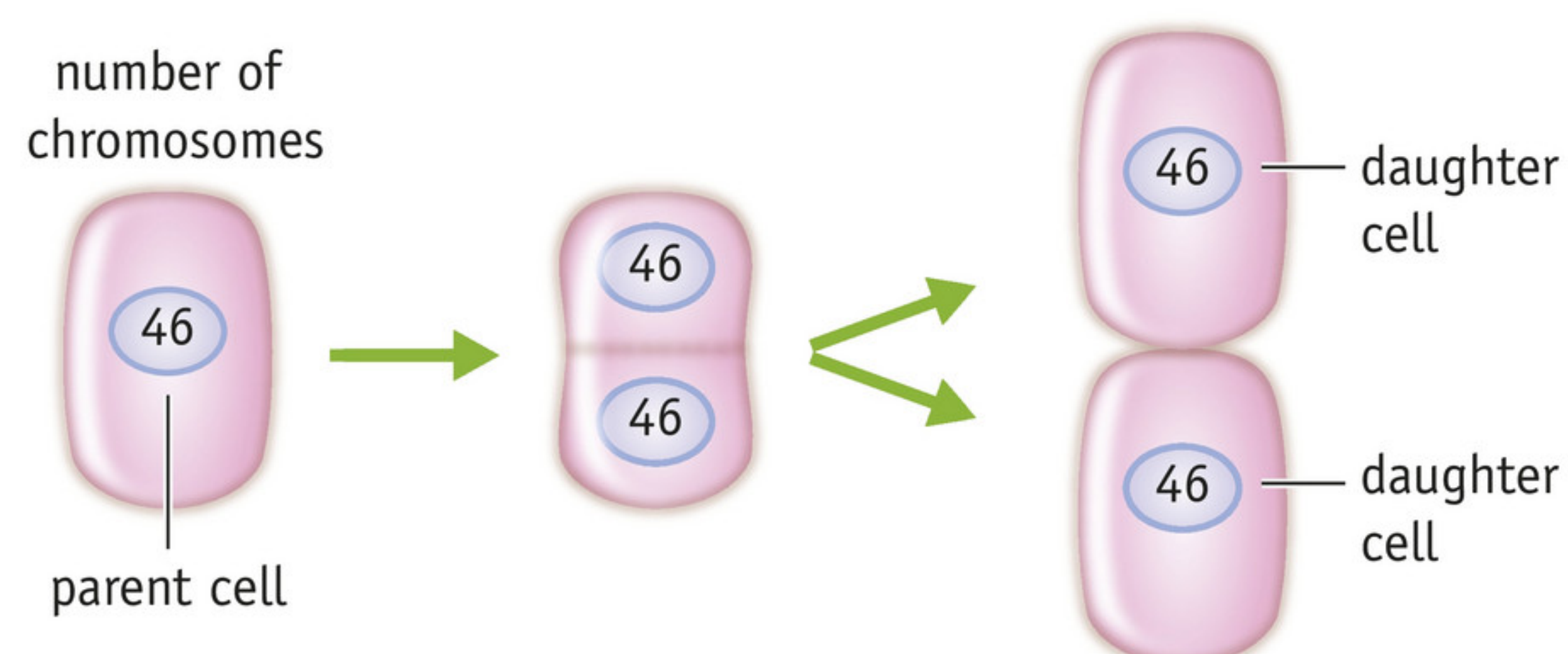
▼ Fig. 11



The fertilised ovum grows into an embryo and then into a baby. Millions of new cells are formed during this growth. New body cells are formed by **cell division**. A **parent cell** divides into two parts and forms two **daughter cells** (see figure 12). These cell divisions do not change the information for the hereditary characteristics (the genotype). The nuclei of the daughter cells contain the same information for the hereditary characteristics as the parent cell.

WB EXERCISES 4 TO 6, PAGE 10

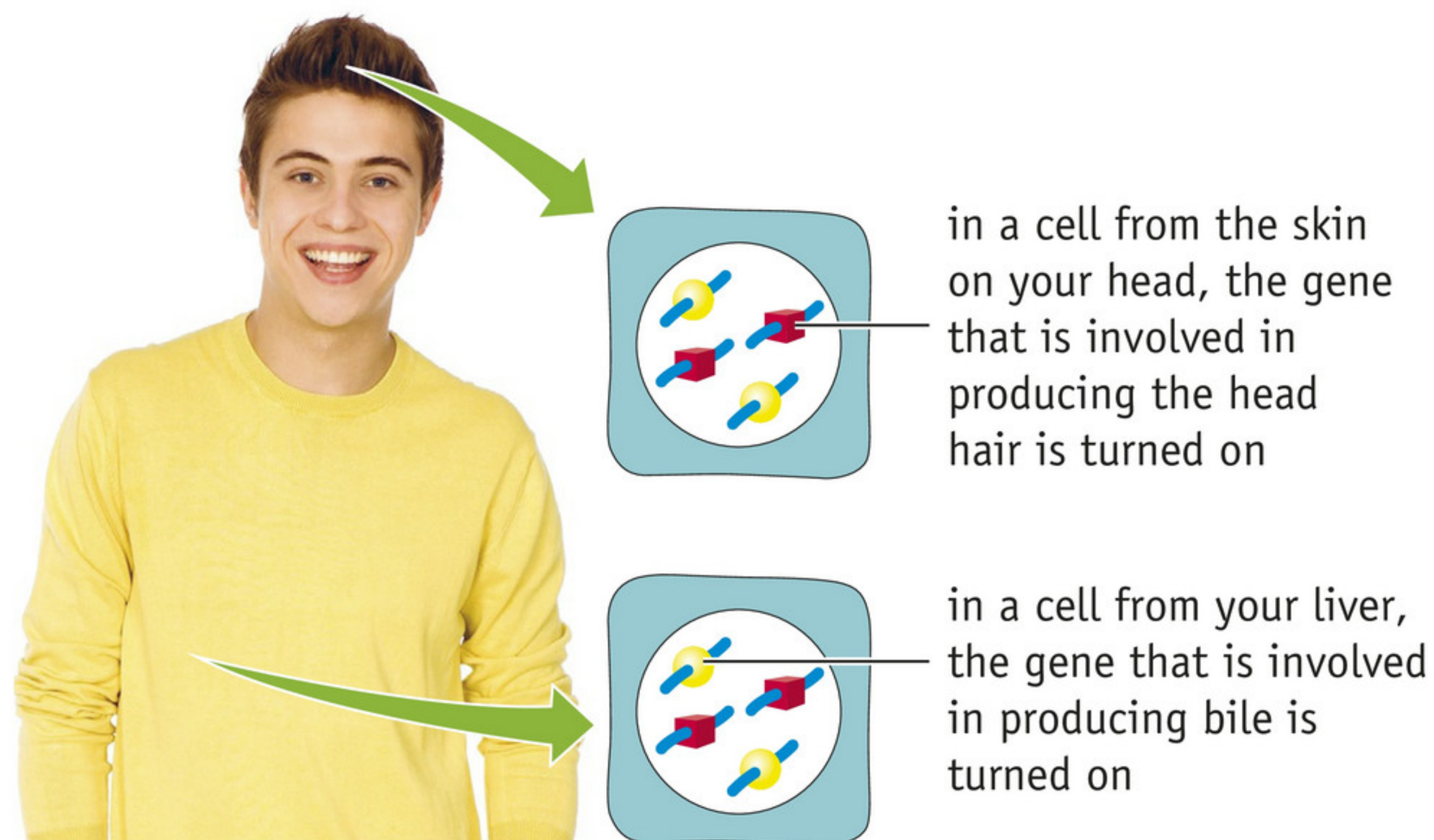
► Fig. 12 Cell division in the body cells of a human (schematic).



GENES CAN BE TURNED ON AND OFF

Genes can be *on* or *off*. A lot of genes are only turned on in certain situations. We say that the gene is only expressed in those situations. Whether a gene is on or off can be different for each cell and depends on the function of the cell (see figure 13). In liver cells, for example, the genes that make sure that bile is produced in the cells are *on*. But the genes in these cells that make sure that hair is formed on your head are *off*. It is the other way round in the skin cells on top of your head. The genes that make sure that hair is formed on the head are turned on there, and the genes that make sure that bile is produced in the cells are off. If a gene is on (expressed), it can be a little bit active or very active (as if turned up 'loud' or 'soft').

► Fig. 13



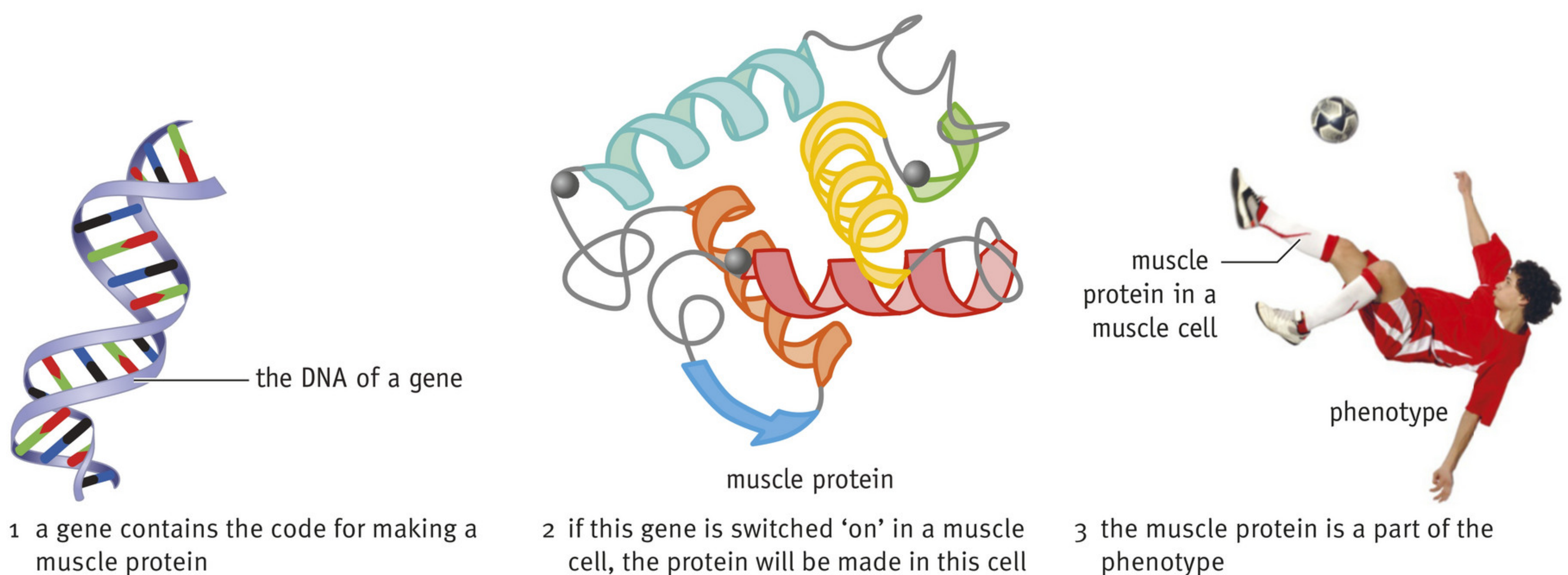
every body cell has all the genes, but cells of the skin have different genes switched 'on' compared with liver cells

FROM GENE VIA PROTEIN TO PHENOTYPE

The DNA sequence for a gene contains the code for making a specific **protein**. A gene in a muscle cell, for instance, contains the code for making muscle proteins. If this gene is turned on in the muscle cell, the code for making a muscle protein is read and the muscle protein is made in the muscle cell. The muscle protein is part of the phenotype (see figure 14).

▼ Fig. 14 From gene via protein to phenotype.

WB EXERCISE 7, PAGE 12



3 Sexual reproduction

Each body cell of every human has an allele pair that contains information for the type of hair. The shape of the hair is a hereditary characteristic. This characteristic is not the same for everyone: some people have straight hair and others have curly hair. The allele pair for the hair type may therefore contain different information for different people. There are alleles with information for straight hair and there are alleles with information for curly hair. These are variants in the gene with information about the hair type.

In some people, the allele pair for the hair type will contain two alleles for straight hair. For other people, the allele pair for the hair type consists of two alleles for curly hair. The two alleles for the type of hair in all these people are identical (see figures 15.1 and 15.2). But there are also people whose allele pair for the hair type has one allele for straight hair and one allele for curly hair. The two alleles for the type of hair are then non-identical (see figure 15.3).

▼ **Fig. 15** Allele pairs for hair type.



1 two alleles for straight hair



2 two alleles for curly hair

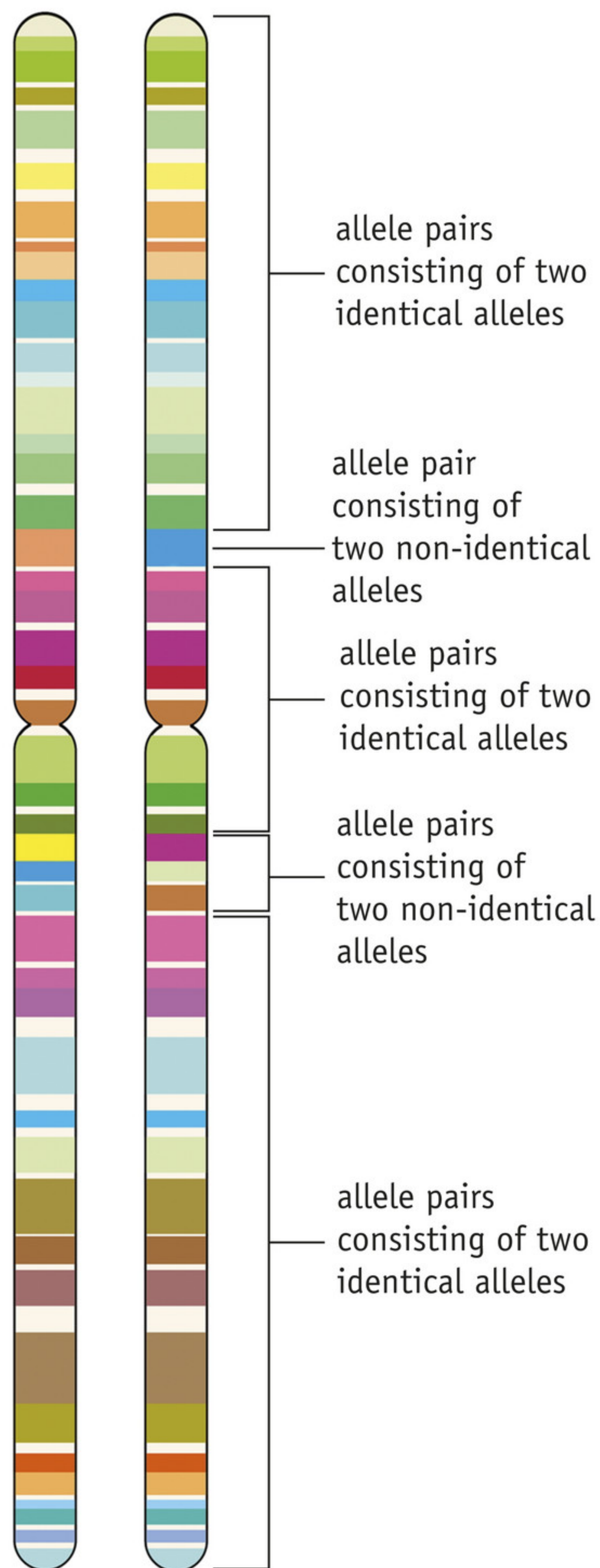


3 one allele for straight hair and one allele for curly hair

Legend:

- allele for straight hair
- allele for curly hair

▼ **Fig. 16** Allele pairs in a pair of chromosomes (schematic).

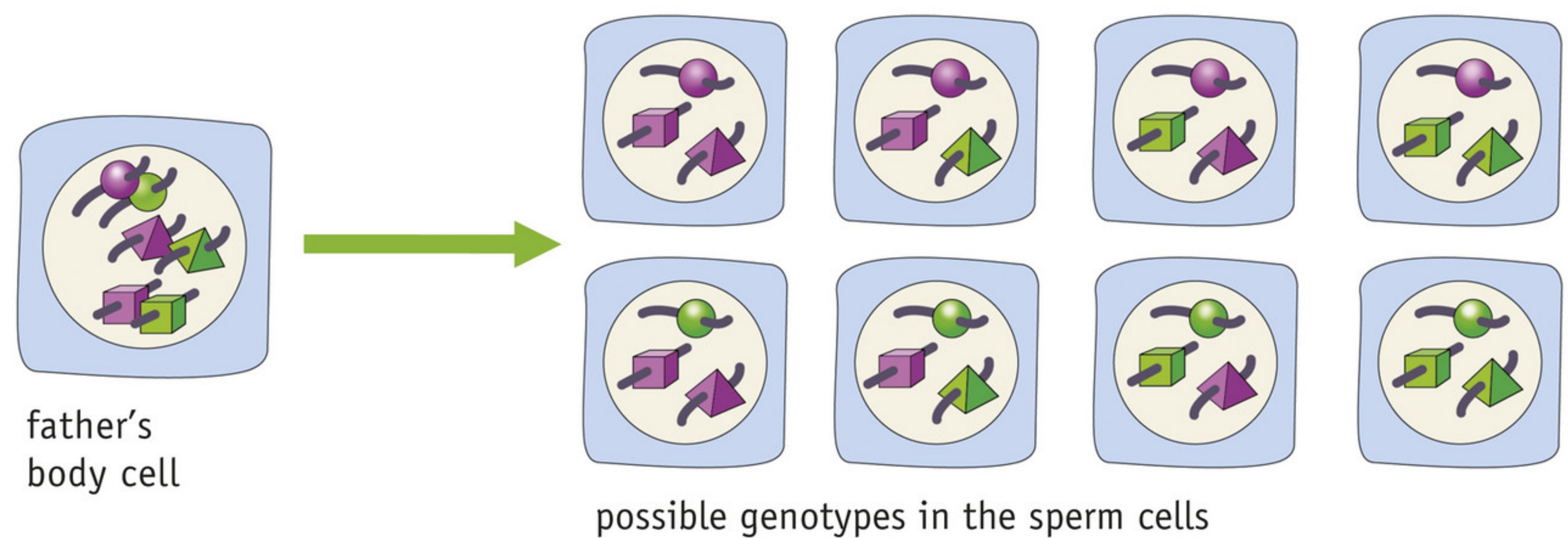


Each pair of chromosomes has a lot of allele pairs. Some allele pairs will be identical. But there are almost always some non-identical allele pairs as well (see figure 16).

You have learned that a body cell has allele pairs (pairs of genes) and a sex cell has single alleles (genes). A sex cell contains only one allele of each allele pair. This also applies to the allele pairs that consist of two different alleles. Which of the two non-identical alleles ends up in a sex cell is a matter of random chance.

Figure 16 is a diagram showing how sex cells originate from a body cell. This is done by a special type of cell division. During this cell division, one chromosome of the body cell of each pair of chromosomes goes into the sex cell. Figure 17 shows three pairs of chromosomes from the father. An allele pair consisting of two non-identical alleles has been drawn in each pair of chromosomes. Just one allele from each of these pairs goes into a sperm cell. As you can see, there are lots of different possibilities. In sperm cells, there is therefore a lot of variation in genotype, just like in the ova produced by a woman.

▼ **Fig. 17** Daughter cells with a lot of variation in genotypes are created when sex cells are formed.



Sexual reproduction creates a new organism when two sex cells fuse. Which genotype the sex cells have depends on random chance. There are lots of different possibilities. The offspring will therefore have a different combination of alleles than either parent. That means the offspring will have a different genotype than either parent.

Sexual reproduction causes variation in the genotypes of the offspring.

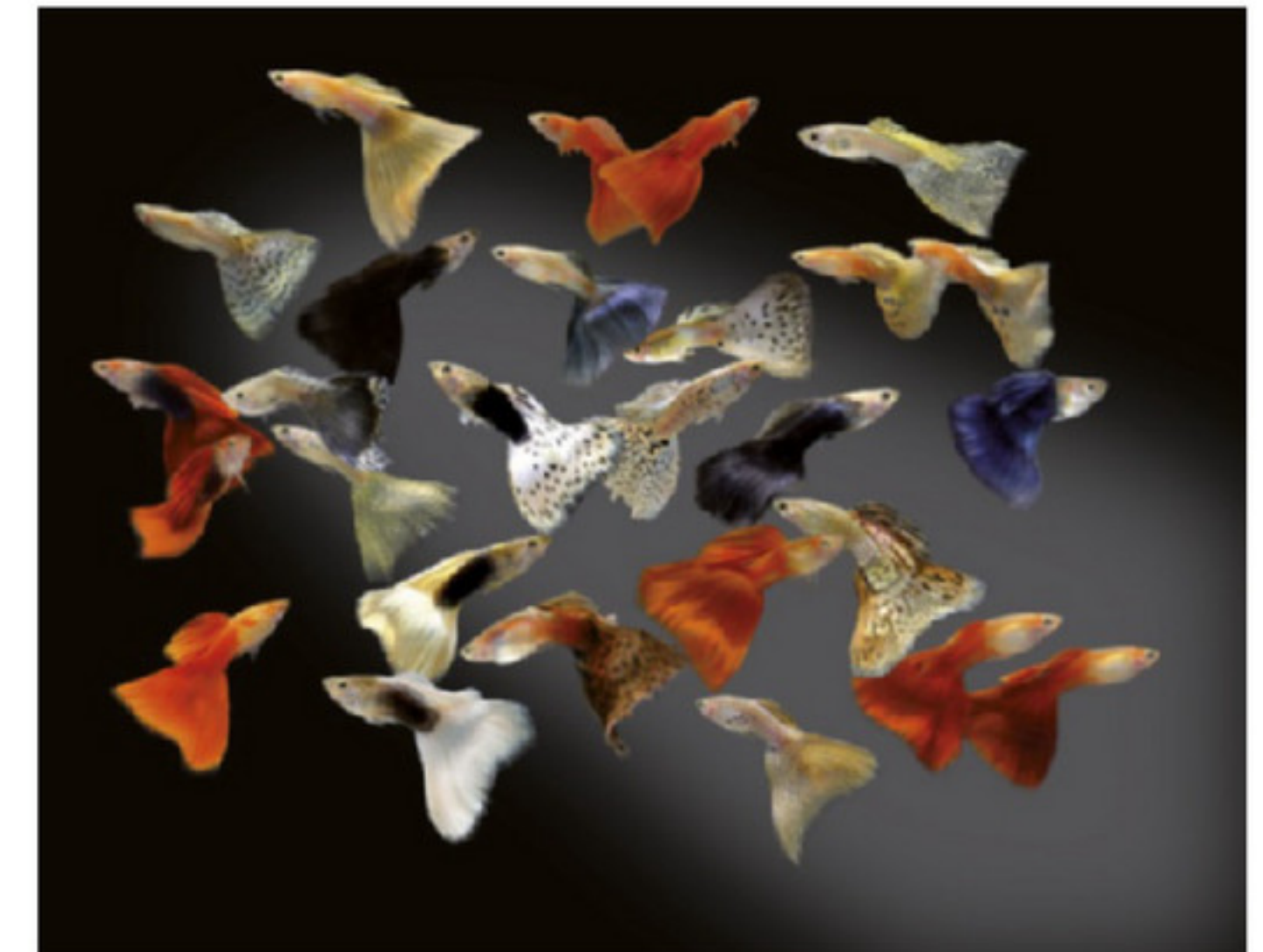
► **Fig. 18** Sexual reproduction creates a variety of genotypes, which sometimes results in a variety of phenotypes too.



1 in humans



2 in the multi-coloured Asian ladybird



3 in guppies

▼ **Fig. 19** Asexual reproduction via bulbs.



the genotypes of the offspring are identical, the phenotypes are very similar

In the extra basics in part 1, you have learned that some plants can also reproduce using **asexual reproduction**, for example through bulbs. Sex cells do not have to fuse for this. Bacteria and some types of fungi can reproduce asexually too. In asexual reproduction, the genotype of the offspring is the same as that of the parent (see figure 19).

WB EXERCISES 8 AND 9, PAGE 14

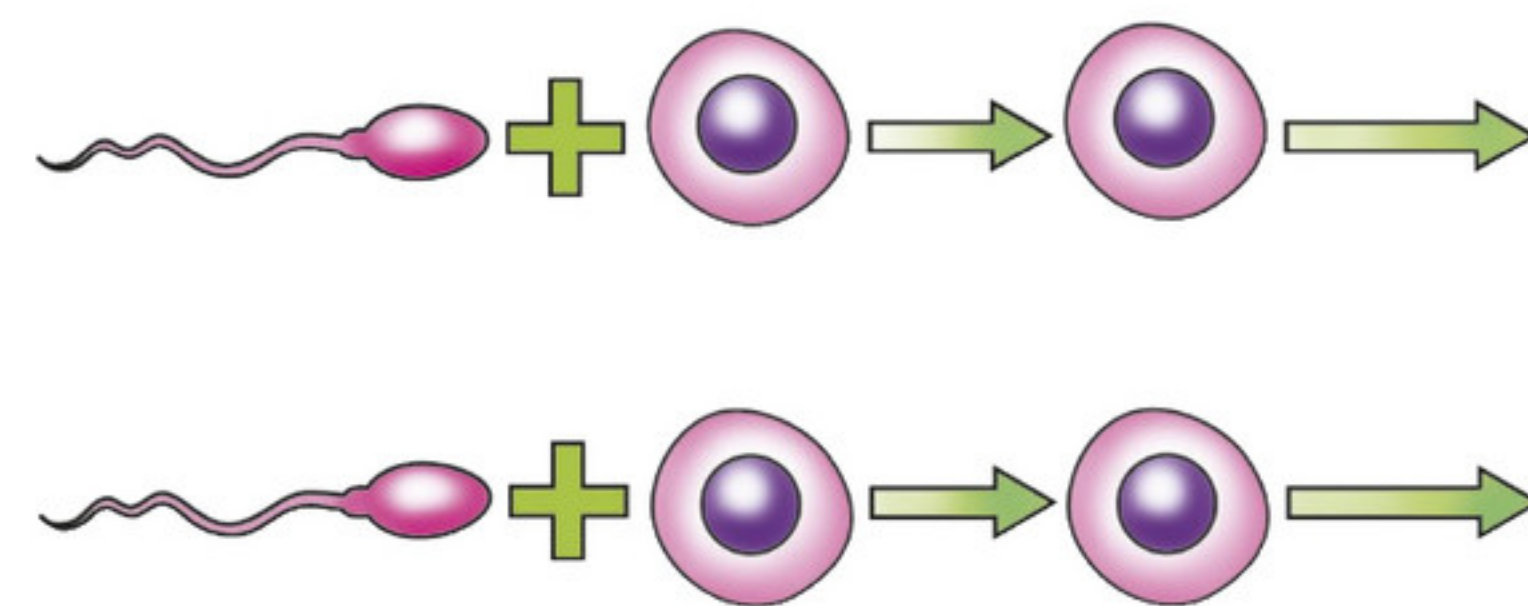
TWINS

In unit 4 (Reproduction), you learned that just one ovum is usually released from an ovary during ovulation. However, two ova can sometimes be released during ovulation. Both of these ova can be fertilised by a sperm cell. Both fertilised ova can generate clumps of cells that implant in the womb's mucous lining. Twins then develop. Twins that originate from two fertilised ova like this are referred to as **non-identical twins** (see figure 20.1).

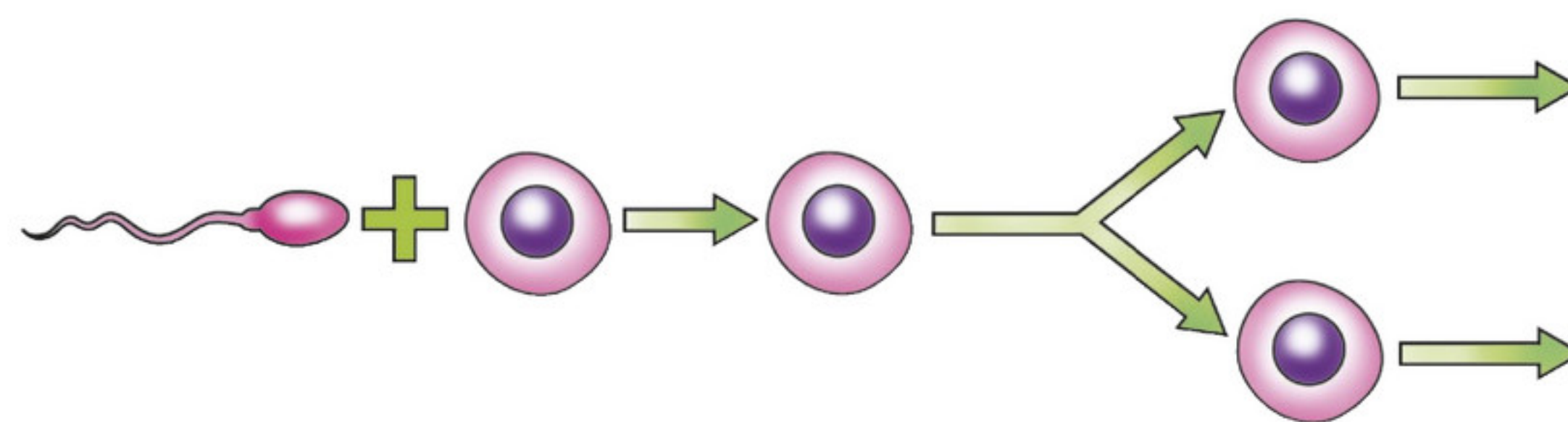
Twins may also originate from a single fertilised ovum. The cells then get separated during the first divisions of the fertilised ovum. Two clumps of cells are then produced that implant in the mucous womb lining. **Identical twins** then develop (see figure 20.2). It is also possible for more than two babies to be born from a single pregnancy (see figure 21).

WB EXERCISE 10, PAGE 15

► Fig. 20 Twins.



1 non-identical twins



2 identical twins

▼ Fig. 21

The Quads

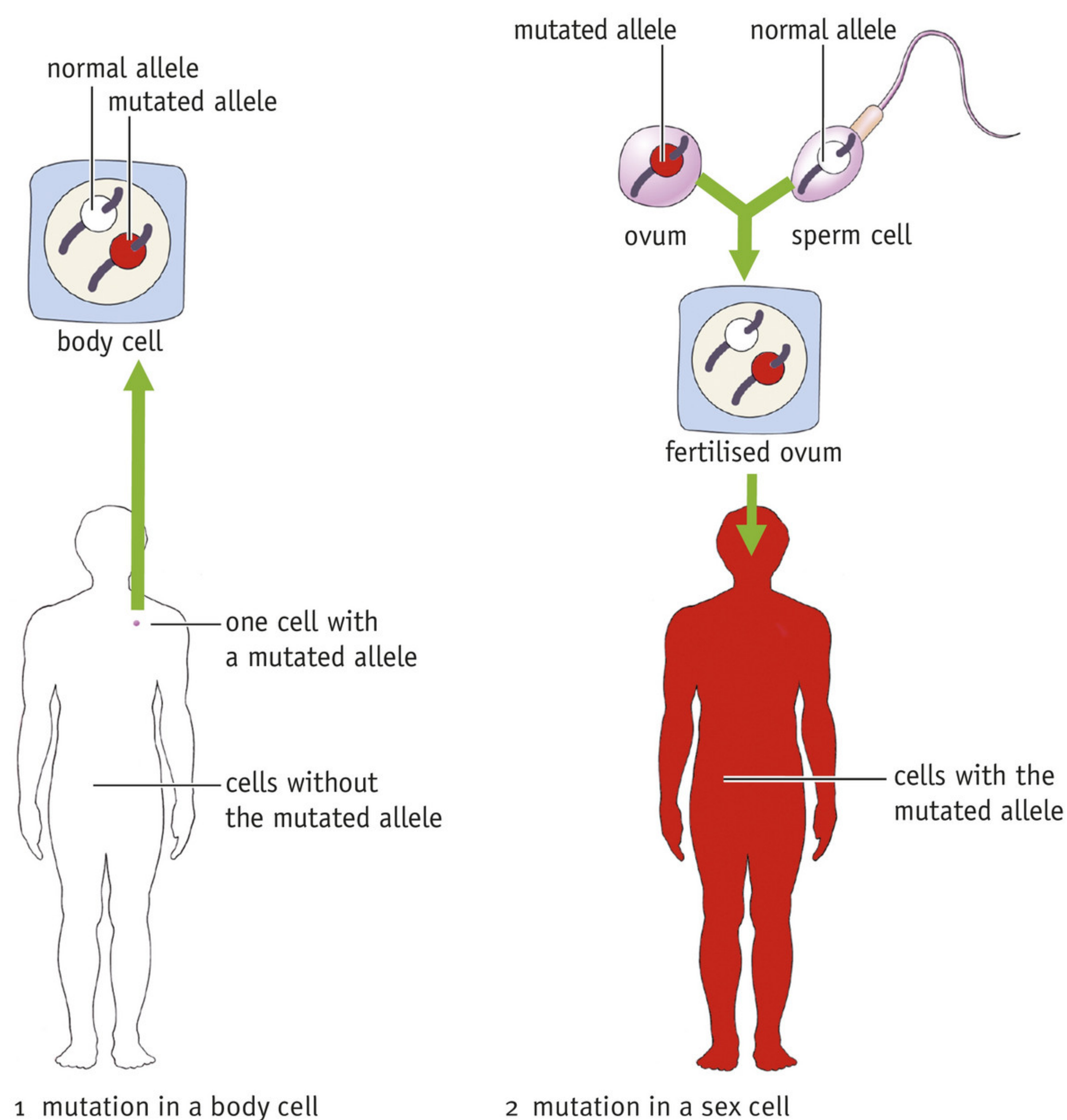
'The Quads' is a TV series about the daily life of a set of identical quadruplets. The teenage girls Tessa, Esmé, Lisa and Bo are like four peas in a pod. People have stared at them all their lives and they are seen as a real attraction. They are therefore used to being in the spotlight. But seeing yourself on the television every day in your own TV series is something new, even for the girls from Hardenberg.



4 Mutations

Chromosomes contain the information for your hereditary characteristics. A chromosome may get damaged and the information for one or more hereditary characteristics may change as a result. Such a sudden change in the genotype is called a **mutation**. In a mutation, one or more alleles have **mutated**. Mutations can take place in any cell. A mutation mostly has no consequences. If a mutation takes place in a certain cell in your body, the other cells in your body will remain unchanged. You will not even notice that you have a cell with a mutated allele (see figure 22.1). But if a sex cell has a mutated allele, the mutation may have a major effect. If this sex cell fuses with another sex cell during reproduction, the mutated allele will be in the fertilised ovum. Every body cell of the offspring that develops from it will have the mutated allele (see figure 22.2). It is then important to see whether the mutated or non-mutated allele is expressed in the phenotype. You will learn more about this in Extra section 9.

► **Fig. 22** The effect of a mutation (schematic).

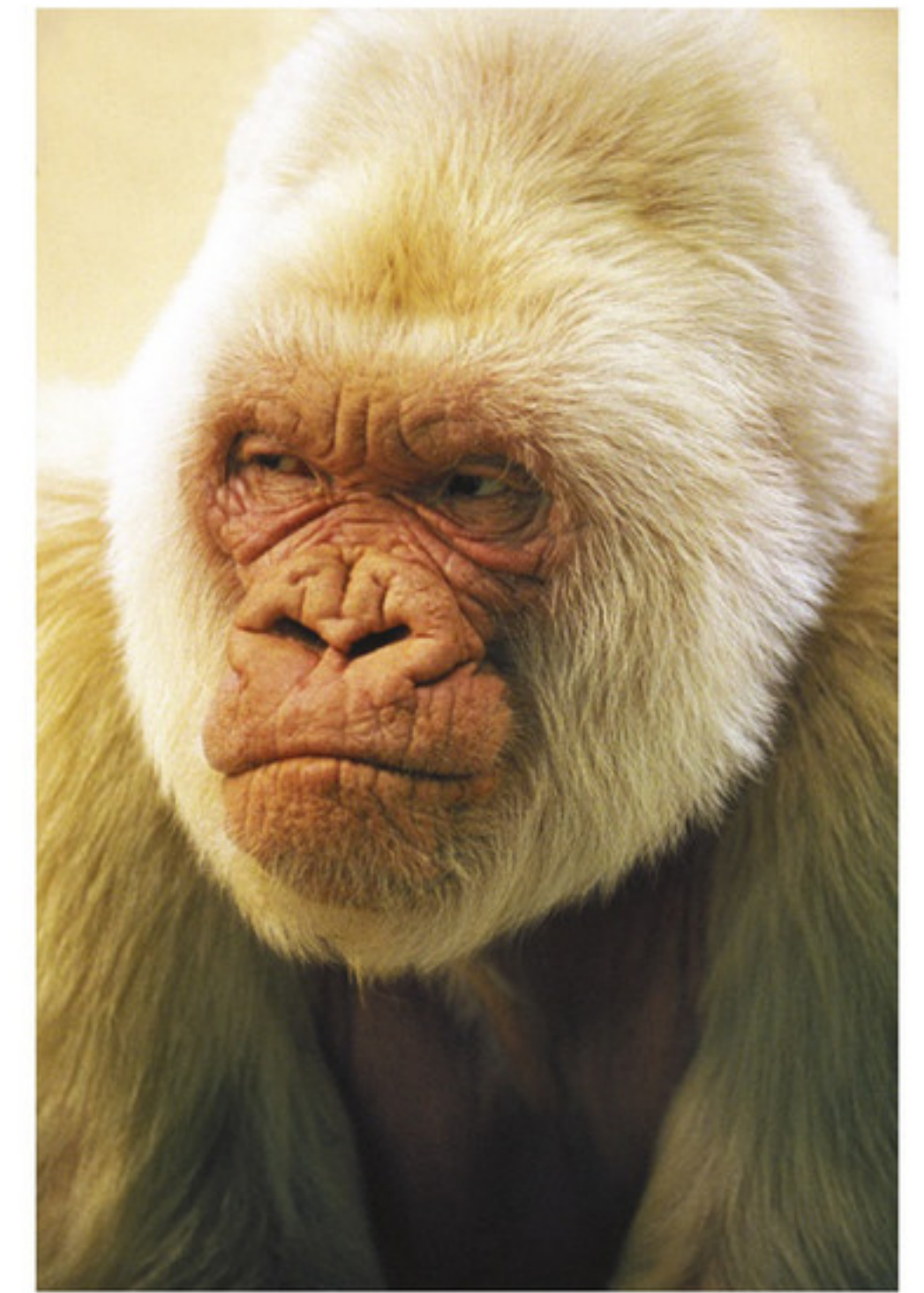


▼ **Fig. 23** Albinism.

An organism in which a mutation can be seen in the phenotype is called a **mutant**. One example of a mutant is an **albino**. The body of an albino is not capable of forming pigment, as a result of which the eyes are red and the organism is very pale (see figure 23). Other pigment mutations also occur (see figure 24). Mutations in pigment genes can be seen very clearly in the phenotype. Most mutations cannot be seen so clearly in the phenotype.

▼ **Fig. 24** Pigment mutations.

1 in a human

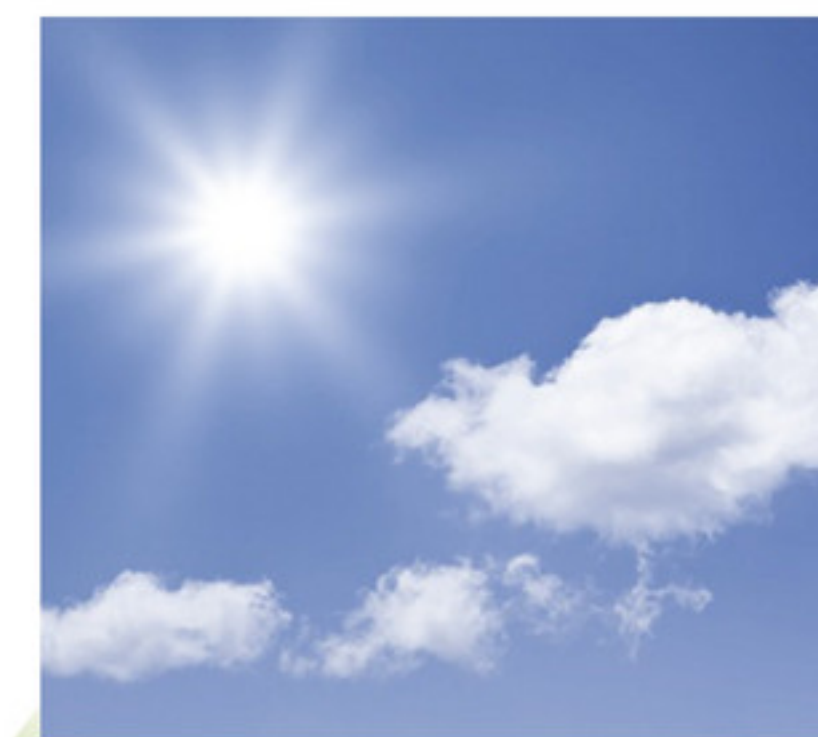


2 in an animal

Mutations can take place spontaneously, but they do not occur often under natural circumstances. If you are exposed to certain types of radiation (radioactivity, X-rays or ultraviolet, for example), mutations will occur in your body more often. If you come into contact with some chemicals (substances in cigarette smoke or asbestos, for example), mutations will also occur more often. Such factors are called **mutagens** or **mutagenic** influences (see figure 25).

► **Fig. 25** Mutagenic influences.

asbestos dust



UV radiation



cigarette smoke



X-rays and radioactivity

MUTATIONS CAUSED BY RADIATION

Mutagenic radiation is released by X-ray equipment, nuclear power stations and atomic bombs, for example. In 1945, two atomic bombs were dropped on Japan. Even today, a lot more children with physical and mental abnormalities are born there than in other countries. The sex cells of Japanese people who were exposed to the radioactivity and their descendants have a lot more mutated alleles than other people.

Special measures are taken at nuclear power stations to make sure that radioactivity is not released into the environment. However, disasters cannot be ruled out. In 1986, radioactive contamination affected large parts of Europe because of an accident at a nuclear power station in Chernobyl (Ukraine). In 2011, there was a nuclear accident at a nuclear power station in Fukushima in Japan after a marine earthquake caused a tsunami (see figure 26). These disasters have made many people cautious about the use of nuclear power.

X-rays also increase the number of mutations. This type of radiation is less harmful than the radiation from atomic bombs or nuclear power stations. Even so, hospitals do not take more X-rays of a patient than strictly necessary.

WB EXERCISE 11, PAGE 17

► **Fig. 26** Rescue workers after the nuclear accident at the Fukushima nuclear power station in Japan.



▼ **Fig. 27** Warning symbol for danger of radioactivity.



CANCER

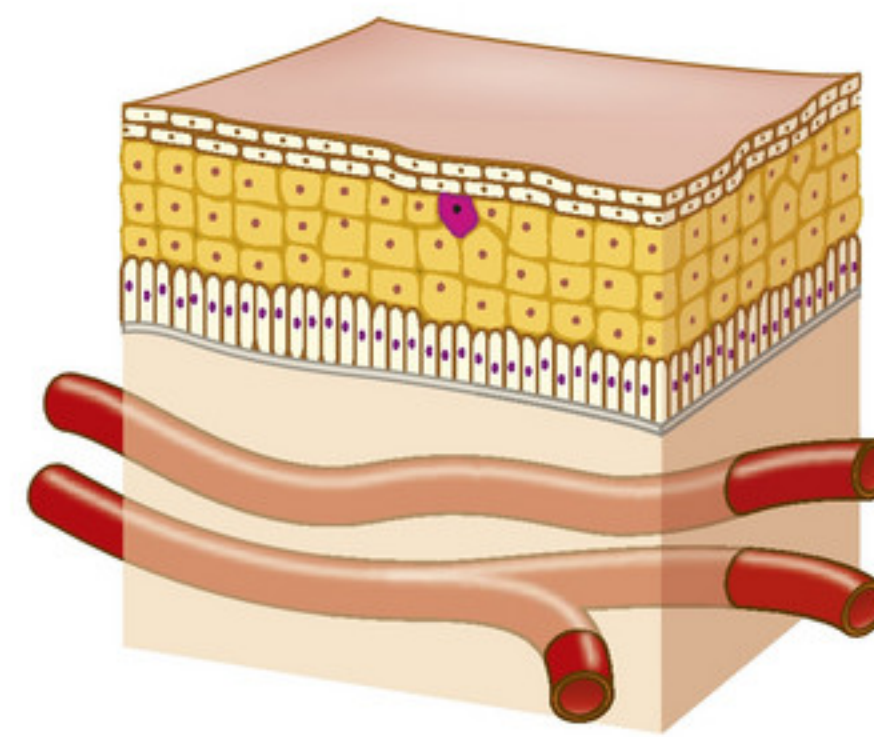
The speed at which cell divisions take place in various parts of the body is precisely controlled. Sometimes, however, cells start to divide rapidly and with no restraints. This then creates a **tumour**.

Sometimes tumours grow slowly and do not disrupt the structure of other tissues. These tumours are referred to as **benign**. If they get too large, they can be surgically removed. After that, the patient is cured.

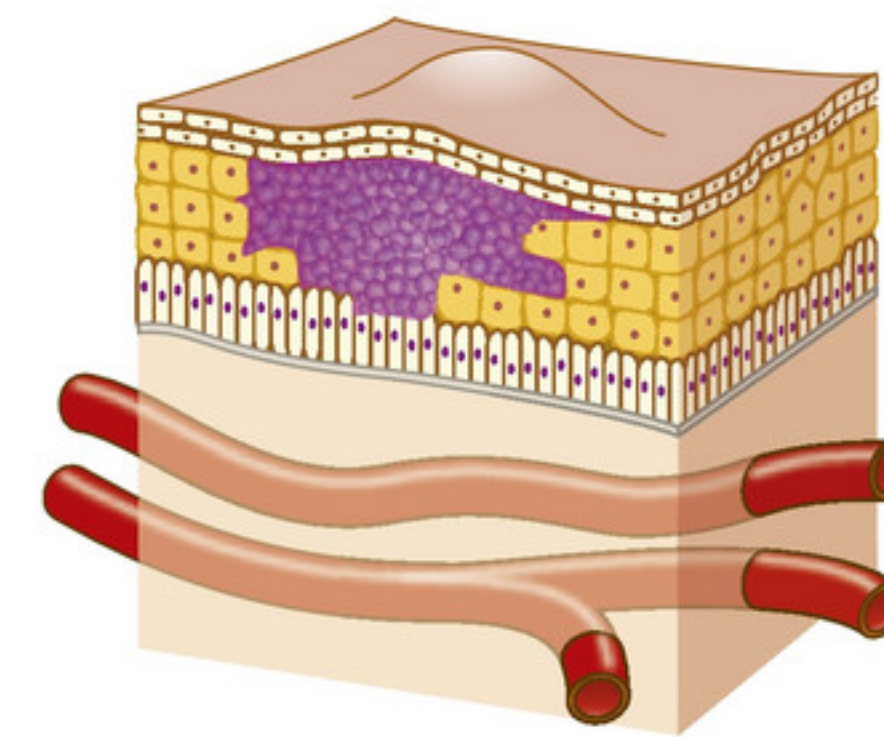
The term **cancer** refers to a **malignant** tumour somewhere in the body. Cancer is caused by certain mutations in genes that help control cell division. These mutations cause uncontrolled cell division. A malignant tumour grows much faster than a benign tumour. It also disrupts the structure of surrounding tissues (see figure 28).

Cancer starts with one tumour. Usually, this first tumour is not lethal. The tumour can be removed surgically, or the cells of the tumour can be killed (by radiotherapy, for example). Most cancer patients die of **metastases**, the name given to new tumours that occur when the cancer spreads. This process of **metastasis** happens when cells from the initial tumour reach the bloodstream or the lymph vessels (see figure 28.4). The cells are then carried along and reach other parts of the body. There they can start dividing uncontrollably again and so tumours arise everywhere in the body. A cure then becomes very difficult because it is almost impossible to detect all these tumours.

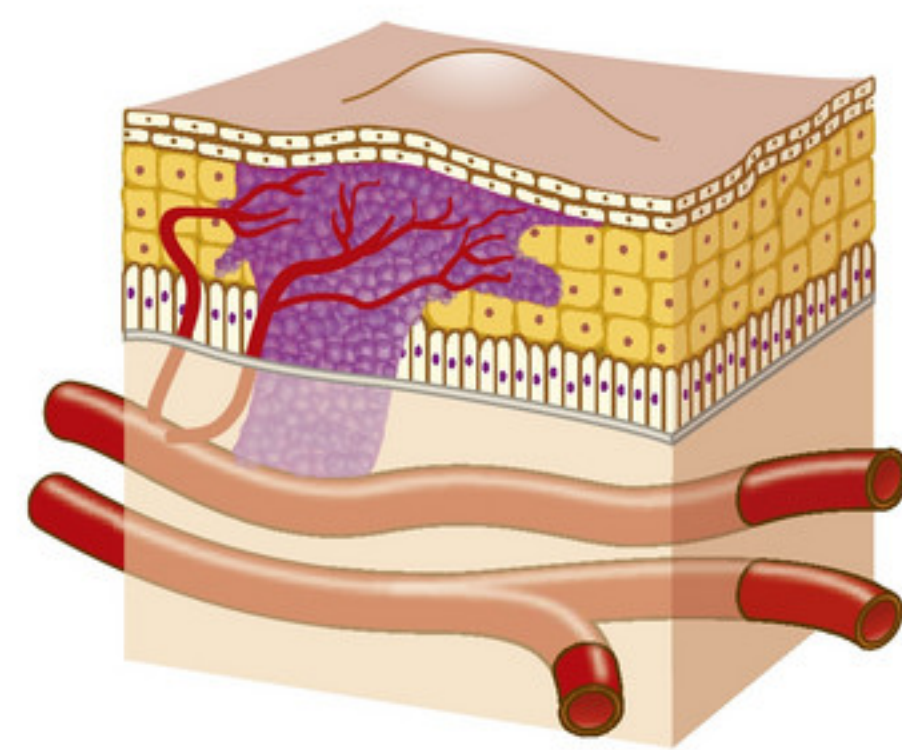
► **Fig. 28** How cancer develops (schematic).



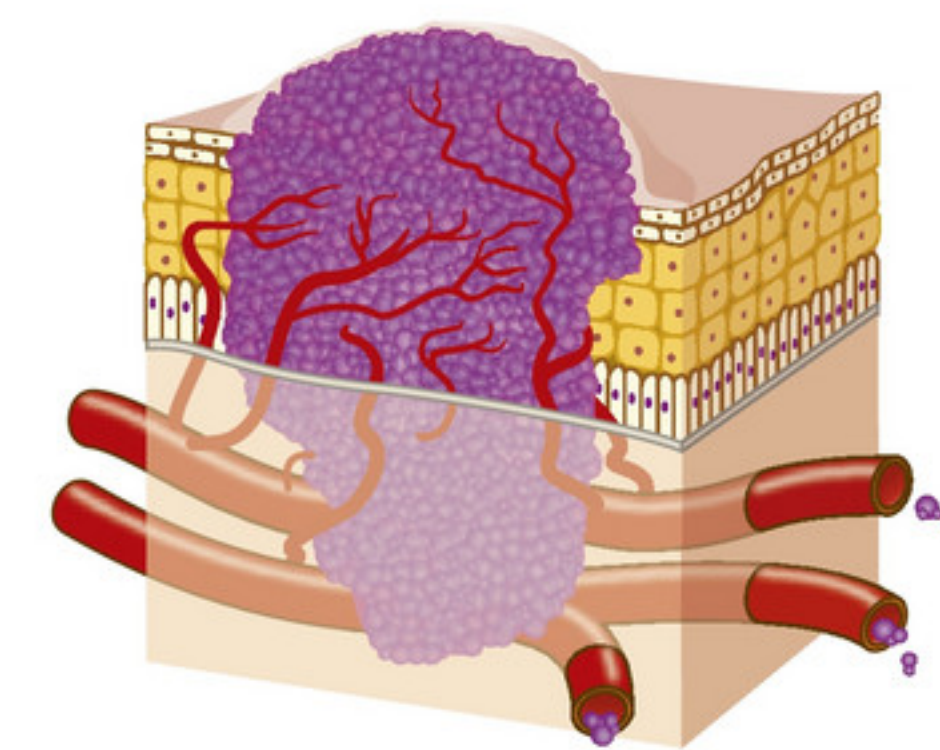
1 a mutation has occurred in one cell: this cell becomes a cancer cell



2 the cancer cell's divisions are uncontrolled



3 a tumour has developed that disrupts the structure of the tissues



4 metastasis occurs: cells from the tumour enter the blood or the lymph vessels

Cancer can often be cured, but only if the disease is discovered in time. A great deal of research is being done into the causes of cancer (see figure 29). All environmental influences that are mutagenic can also cause cancer. Long-term exposure to the ultraviolet radiation in sunlight, for example, increases the risk of skin cancer (see figure 30). Inhaling asbestos dust or substances from cigarette smoke increases the risk of lung cancer.

▼ Fig. 29

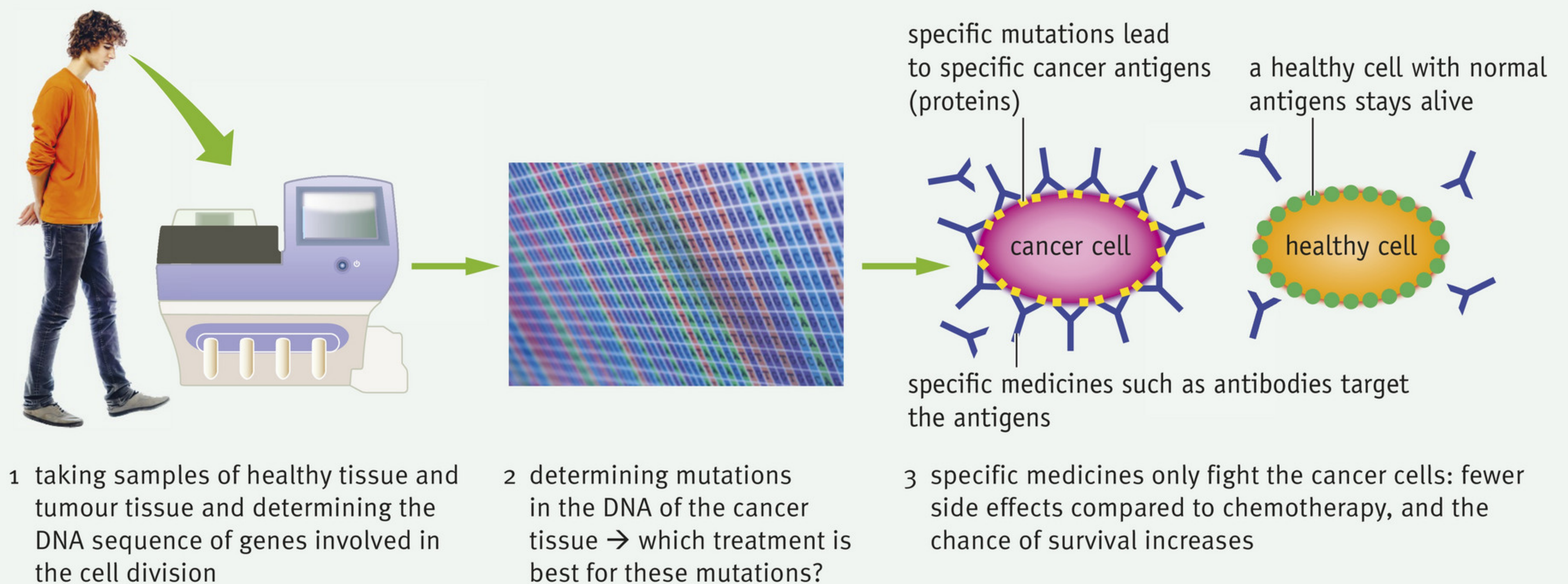
Computational biologist

Hello. I'm Martin. I am a computational biologist working on cancer research. There are a lot of genes that play a role in cancer. There are also more and more types of treatments for cancer. In this research, I am trying to find out which treatment is best suited to a certain mutation in a certain gene. For example, it can turn out that for a certain mutation in gene A, a treatment has a positive effect in 80% of the patients, but for a mutation in gene B, this treatment only works in 6% of the patients.

In reality it is even more complicated. Mutations in gene A may for example occur at twenty different points, but some of those mutations do not cause

breast cancer while others do. Or a particular medicine may work well against breast cancer that is caused by one specific mutation in gene A, whereas the same medicine has little or no effect against breast cancer caused by a mutation at a different point in the gene. Until recently, cancer patients were often given chemotherapy. This slows down cell division in rapidly dividing cells. Not only of cancer cells, though, but also of healthy cells that divide rapidly. The rapidly dividing cells in the follicles of the skin on your head, for example, are also affected by chemotherapy, and so it makes you go bald. These side effects occur much less in targeted cancer therapy (see the figure).

Targeted cancer therapy



▼ Fig. 30

One in six Dutch people will get skin cancer

AMSTERDAM – One in six Dutch people will probably get skin cancer. That's a lot of people. Treatment will therefore lead to an enormous increase in healthcare costs. This prediction was made by the Dutch Skin Foundation, prior to a conference to be held on Friday in Amsterdam. According to the Skin Foundation, the number of people who have skin cancer is

still not being recorded properly. That is why it is difficult to predict how often the disease occurs. The increase in skin cancer is caused by the ageing population, the Skin Foundation says. In the past, many elderly people were exposed to sunlight for a long time without protecting themselves against the radiation. In those days, people were not warned against it.



5 The theory of evolution

▼ **Fig. 31** The forms life takes can vary widely.



1 lovebird (a small parrot)



2 black truffle



3 leopard



4 armadillo

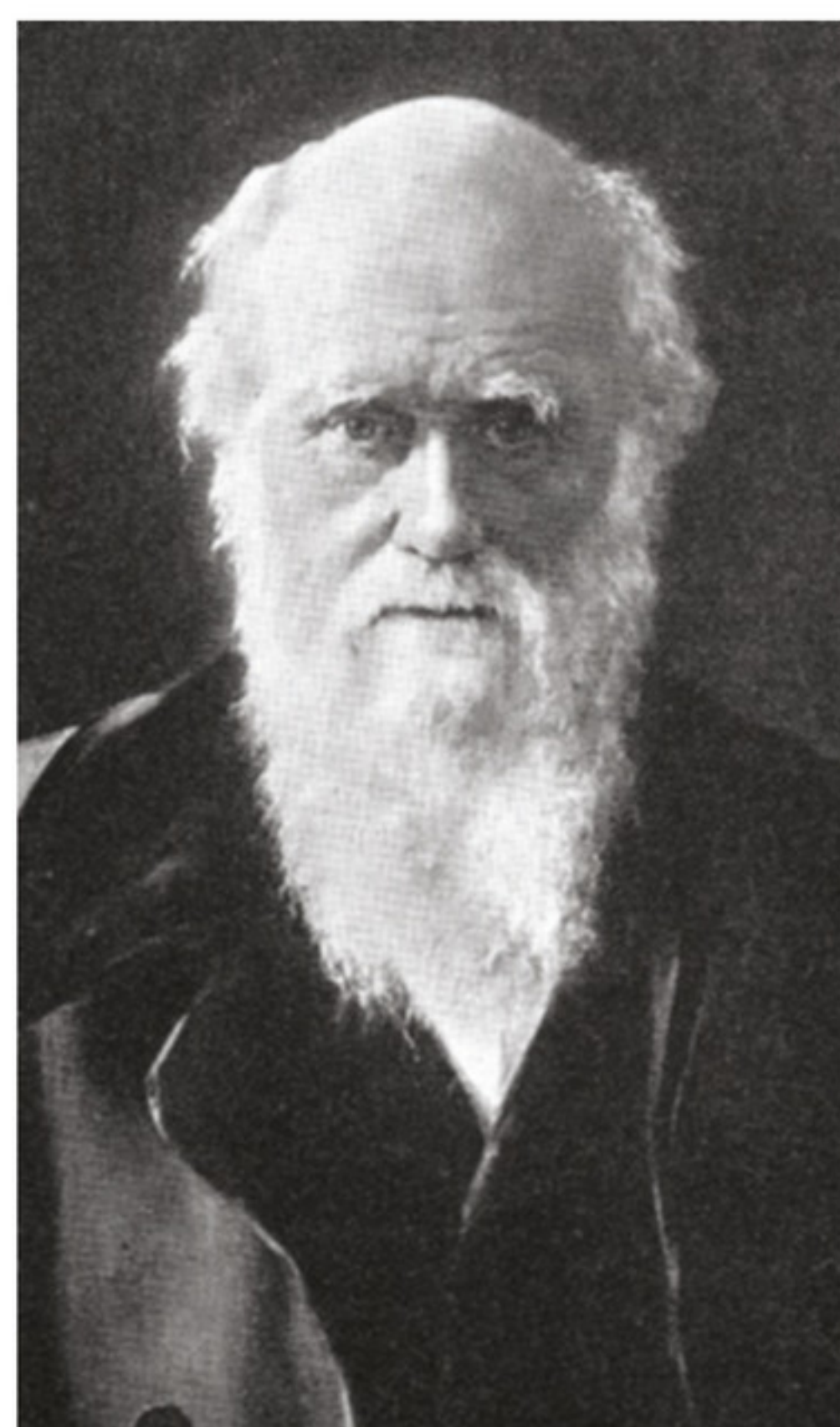


5 bird of paradise flower



6 milk snake

▼ **Fig. 32**



Charles Darwin (1809–1882)

There are millions of different species of organisms on Earth. These forms of life can look very different (see figure 31). Biologists are convinced that the life forms on Earth have appeared and changed over the course of a very long time. The development of life on Earth, with species appearing, changing and/or disappearing, is known as **evolution**.

Until the nineteenth century, people generally thought that all species had always existed unchanged. The **theory of evolution** was developed from the eighteenth century onwards. This theory cannot be proved, but there are many facts that make it likely. These facts form arguments in favour of the theory of evolution. You will learn about the key arguments in basics 7.

The theory of evolution was mainly developed by the English scientist Charles Darwin. His ideas were worked out further by other scientists later on. Discoveries in genetics in particular have been very important for this. The theory of evolution is based on variation in genotypes, natural selection and the formation of new species.

VARIATION IN GENOTYPES

Most plants and animals reproduce sexually. You learned that organisms with new genotypes are created as a result of sexual reproduction and mutations. This causes **variation in genotypes**.

You also learned that the phenotype of an organism is defined by the genotype and by environmental influences. When new genotypes are created as a result of sexual reproduction and mutations, this can also create new phenotypes (see figures 17 and 18). Variation in phenotypes also occurs in humans (see figures 33 and 34).

▼ Fig. 33 Variation in phenotypes in humans.

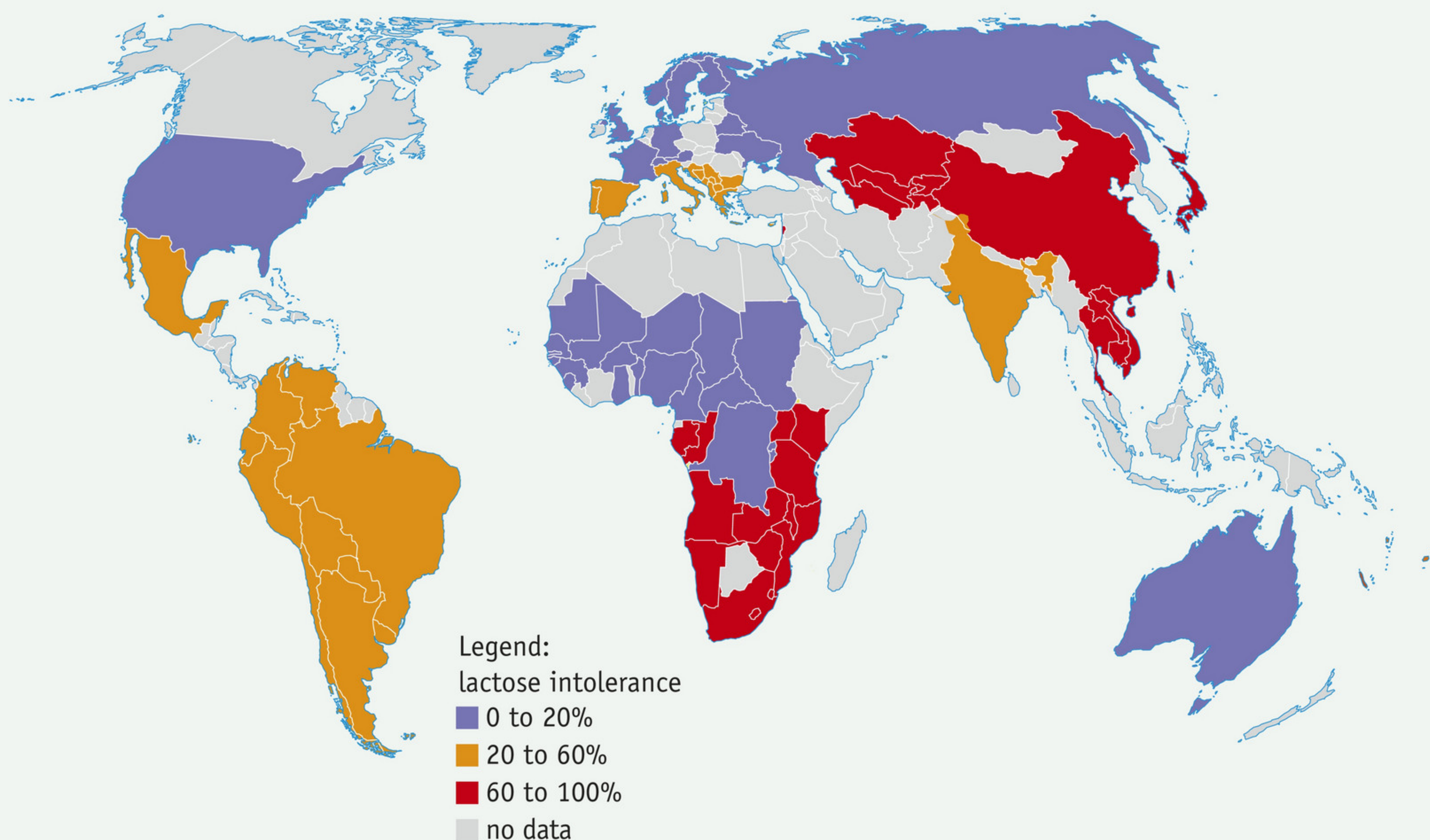


▼ Fig. 34

Lactose intolerance

Drinking milk is very normal for many people. So much so that they do not think about the fact that many adults in countries outside Europe cannot tolerate milk products well. These people were able to tolerate milk as a baby or young child, but when they switched to different food, they lost the ability to digest milk well and it now gives them abdominal pains. This is known as lactose intolerance.

The indigestible sugar lactose is an important component of milk. Children produce the enzyme lactase, which splits lactose up into smaller sugar molecules that can be digested. Because of a mutation, the gene with the code for the protein lactase remains active in some people, even when they became adults. People with this mutation had an advantage once humans started to keep cattle and to drink cow's milk.



NATURAL SELECTION

Some organisms have a lot of offspring. A female frog, for example, can lay as many as three thousand eggs in a pond in a single spring. But the pond does not contain enough food for that many frogs. Not all of the frogs from these eggs can therefore remain alive. A tough selection battle takes place, and only a few of the offspring will grow to maturity and have their own offspring.

Not all frogs have an equal **chance of survival**. Frogs that are less healthy or are strikingly coloured will soon fall prey to predators. These frogs only live a short time and do not have much chance to have offspring. Frogs that are healthy and strong and with good camouflage colouring have the greatest chance of staying alive and having offspring. Darwin called this phenomenon **natural selection** (see figure 35).

► **Fig. 35** Natural selection.



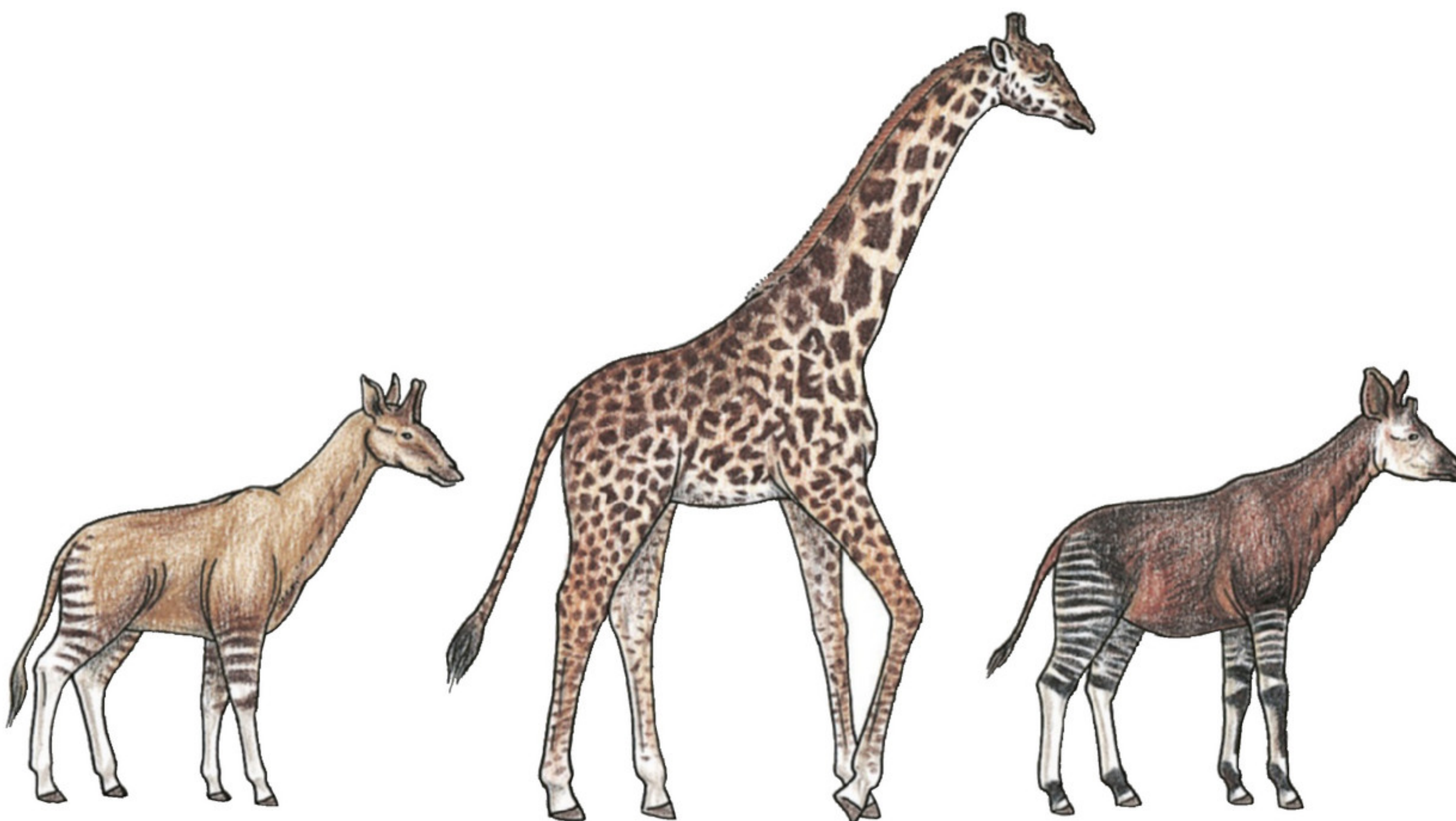
1 in the offspring of a frog



2 in the fruits of a beech

The ancestors of giraffes, for example, were about the same size as zebras (see figure 36). These ancestors mainly ate grass. It is thought that some animals had a mutated gene that gave them a somewhat longer neck. These animals had an advantage, because they could eat leaves from trees more easily (see figure 37). This gave them a better chance of survival. At times when food was scarce, many of the animals with short necks died from a lack of food. The animals with longer necks stayed alive and reproduced. Centuries of natural selection may have created giraffes with longer and longer necks.

▼ **Fig. 36** The evolution of giraffes.

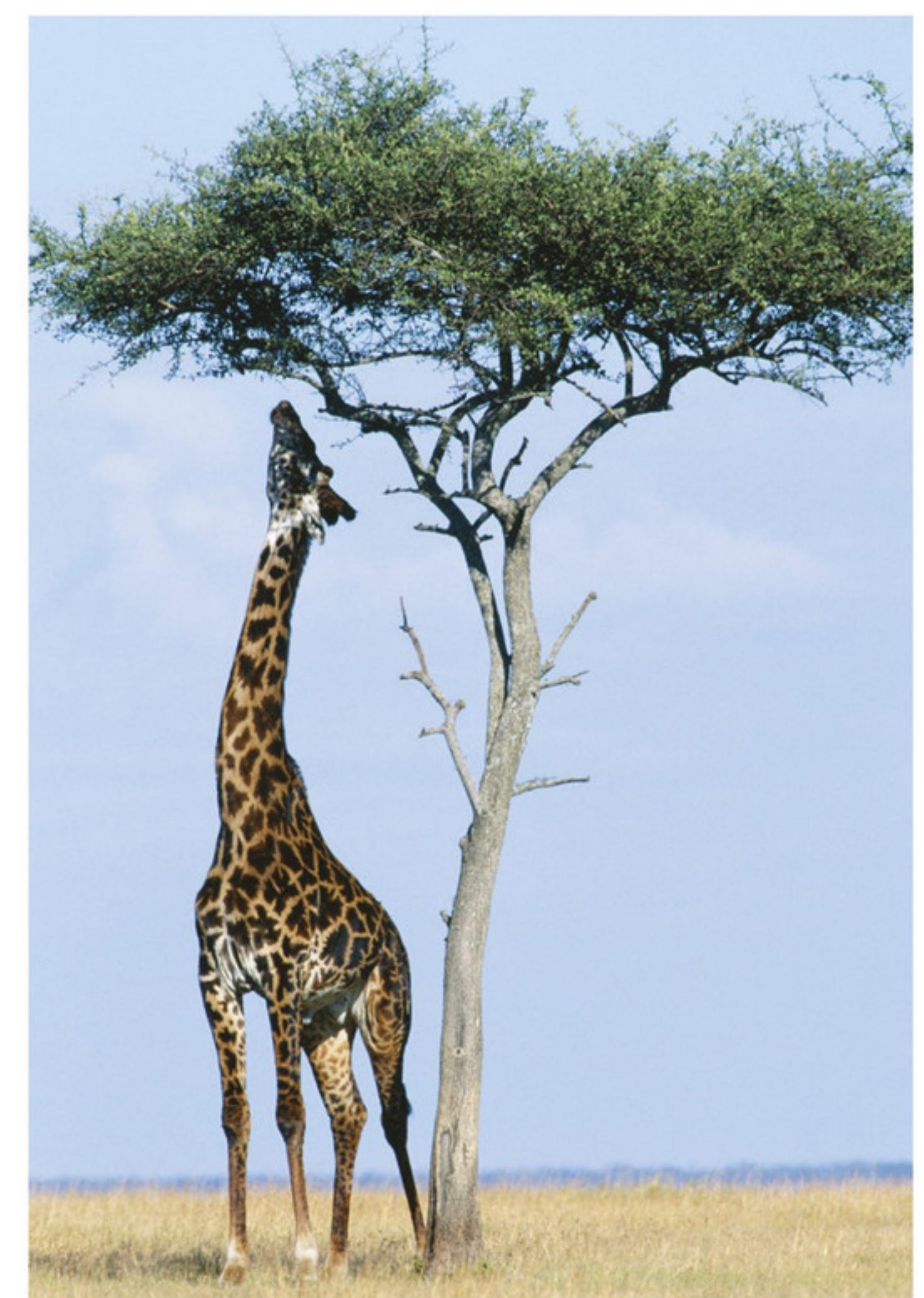


1 extinct ancestor of the giraffe

2 giraffe

3 okapi, the only modern animal related to the giraffe

▼ **Fig. 37**



How well adapted an animal is to the environment can vary. This is mainly determined by the genotype. An animal that is well adapted to its environment has a greater chance of survival. A lot of this animal's offspring will stay alive and reproduce. The favourable genotype is passed on from parents to offspring in this way.

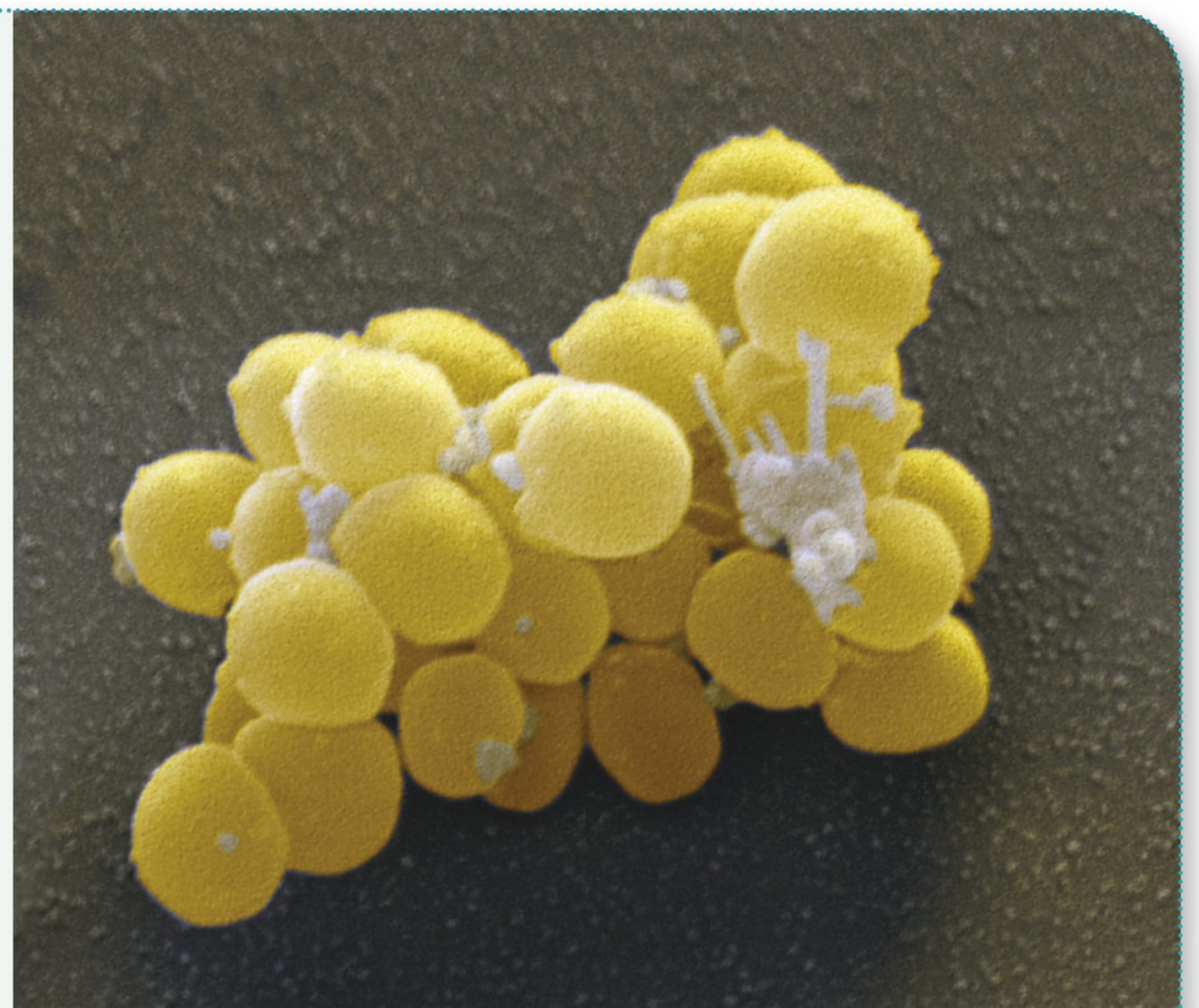
An animal that is poorly adapted to its environment will have few or no offspring. The unfavourable genotype is therefore much less likely to be passed on to offspring. This applies to all organisms, not just animals. Selection makes sure that species are changing continuously. Figures 38, 39 and 40 show examples of changes in genotype and phenotype in bacteria, animals and humans.

▼ Fig. 38

Natural selection in hospitals

The bacterium *Staphylococcus aureus* has become a problem in many hospitals. This is because some of the bacterial strains have mutated to become resistant (insensitive) to antibiotics. It is therefore very difficult to fight the bacterium. The resistant bacteria are called MRSA bacteria. These bacteria have a gene that makes it possible for them to break down antibiotics.

Antibiotics have been used since around 1940 to kill bacteria. A lot of antibiotics are used in hospitals in particular. That is why MRSA infections occur in hospitals in particular. The bacterium is therefore also known as the 'hospital bug'.



MRSA bacteria

You have learned that mutations can lead to new genotypes. If mutations are expressed in the phenotype, this will almost always result in a smaller chance of survival for the mutants. The mutants will not have many offspring. These mutated alleles will therefore not be passed on to the offspring very often. Only very occasionally will there be a mutation that results in a better chance of survival or a greater chance of reproductive success for the mutant. In that case, the mutants will have more offspring than the original form. In the long run, the mutated gene will then often be found in the descendants (see figure 39).

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▼ Fig. 39

Tasmanian devil reproduces more rapidly because of disease



The Tasmanian devil is a marsupial – a pouched mammal – that lives on the Australian island of Tasmania. For the last twelve years, the animals have been suffering from a fatal and contagious disease. In some areas, 90% of the animals have already died of this disease. There is therefore a danger that the Tasmanian devil could become extinct in the longer term. However, for the time being, the animal is still managing to survive. A small proportion of the animals have genes that let them reproduce as early as the first year of their life. That gives these animals a larger chance of reproducing: they already have young before they die of the disease. In some areas, 60% of the animals are now already reproducing during the first year of life.



Tasmanian devils
before the outbreak
of the contagious
disease



Tasmanian devils
after the outbreak
of the contagious
disease

Legend:

 allele for slow reproduction

 allele for rapid reproduction

▼ Fig. 40

Tibetans

European tourists travelling on a mountain tour high in Tibet soon notice that their Tibetan travel guides can easily climb for hours, whereas they get tired after just a few hundred metres. The explanation for this is that the air at a high altitude gets thinner and contains less oxygen than at sea level. Research has also shown that 87% of the Tibetans have an allele that lets their lungs absorb more oxygen on average than people who live in lowland areas. More than 4000 years ago, a group of Han Chinese travelled from the lowland to the Tibetan plateau. Only 9% of the Han Chinese in the bordering lowland have this allele.



THE FORMATION OF NEW SPECIES

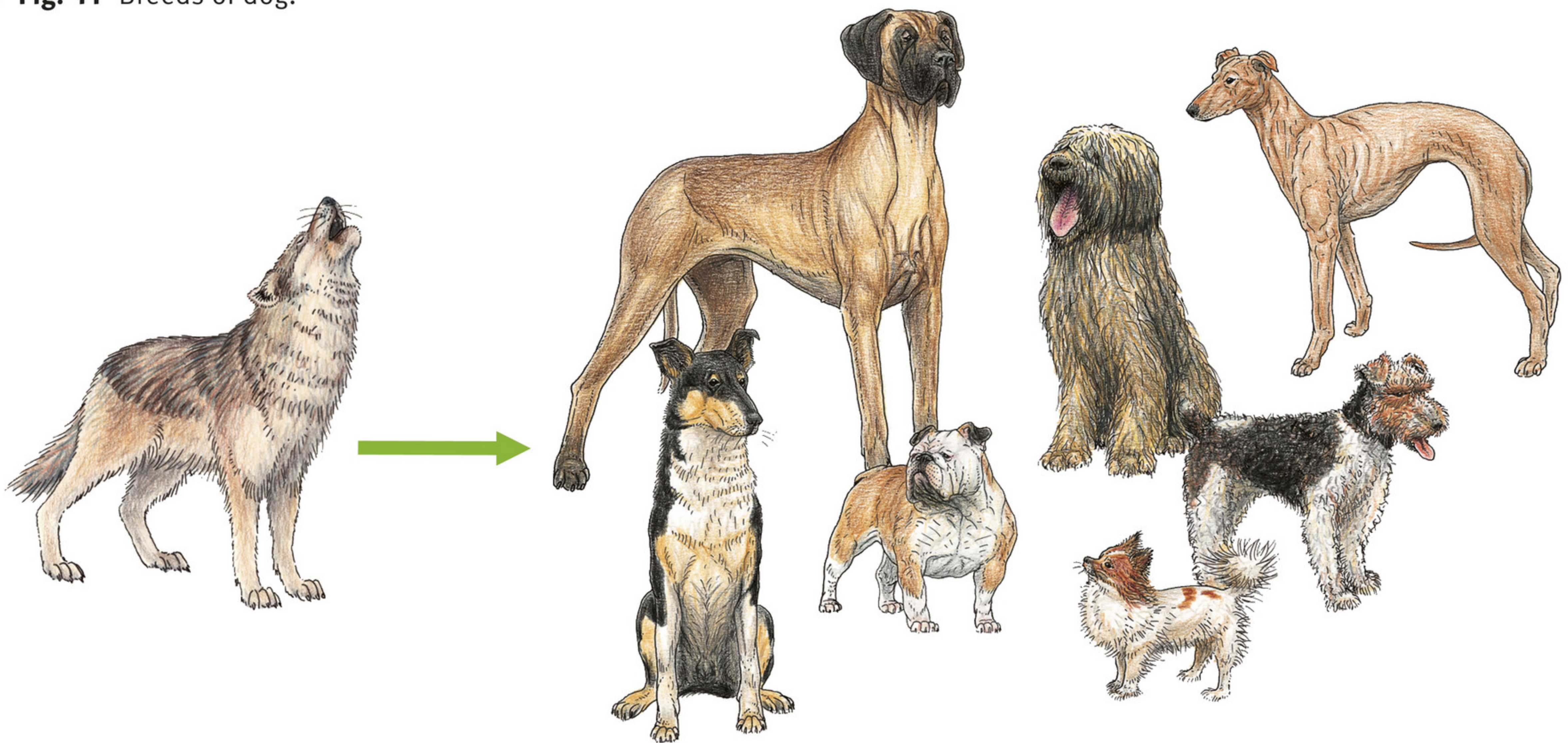
It is important for a species' chance of survival that the species has a lot of different genotypes and phenotypes. The species has then a better chance of survival, particularly when environmental conditions are changing.

The climate can change, for example. In that event, a lot of variation in genotypes and phenotypes is favourable because there is then a good chance that some organisms will adapt well to the new climate. This may mean that the organisms with the original form will become extinct. The organisms with a new, different form will continue to exist. The species has then changed.

It is also possible that both forms continue to exist alongside each other. Organisms with the original form and organisms with the new, different form reproduce amongst themselves then. This then usually results in all kinds of intermediate forms. As long as the various forms continue to reproduce amongst themselves, they will continue to be part of the same species. A new species will then not arise. However, there may be different forms of one species. One example is the many different dog breeds (see figure 41). They all belong to a single species.

The different forms of one species may be separated and become isolated from each other, for example, by a river, mountains, ice, a desert or a sea. In the long term, **isolation** may result in separate species. This is because the two forms become more and more different from each other. After a long time, organisms of the two forms will no longer be able to reproduce with each other and still have fertile offspring. The two forms have then become two species.

▼ Fig. 41 Breeds of dog.

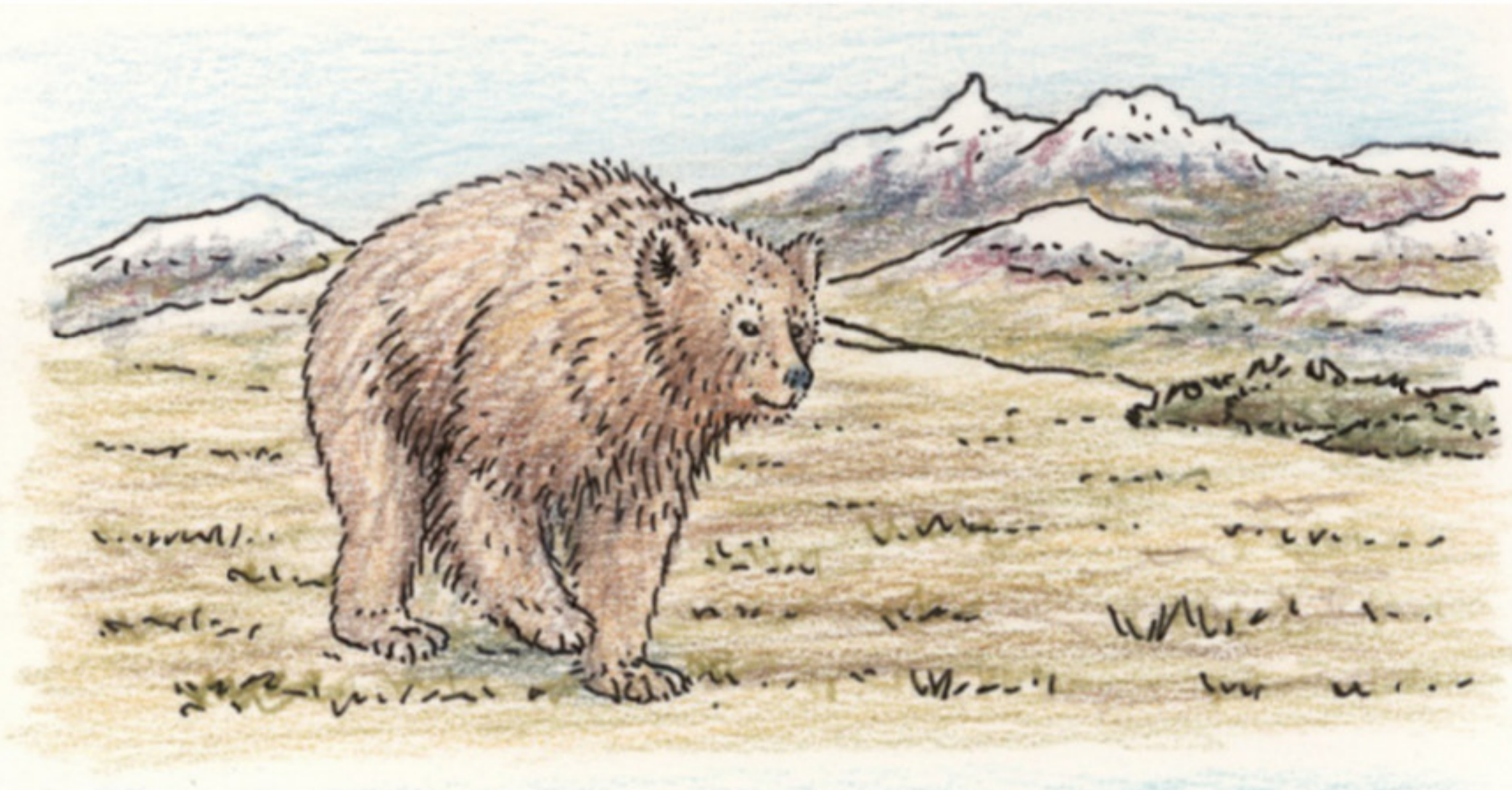


The same can happen when one group of organisms of a species becomes isolated from the rest of the species. Their environment can change over the course of millions of years. This triggers adaptation to the different environments, for example for the bears in figure 42. The lemurs of Madagascar are another example of species being formed as a result of isolation (see figure 43).

▼ Fig. 42 Formation of a new species through isolation (schematically).



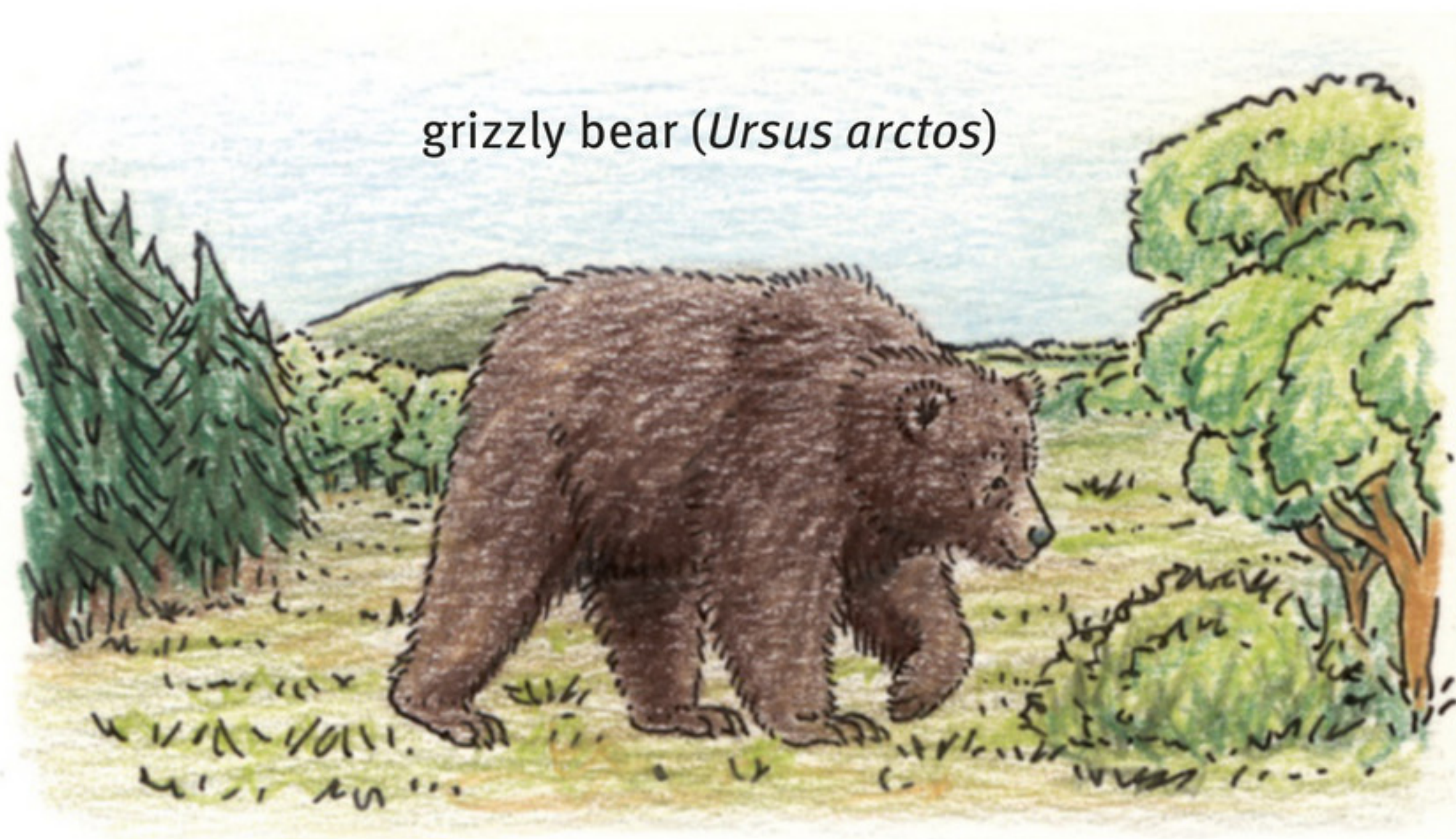
1 Bears of a single species live in a certain area.



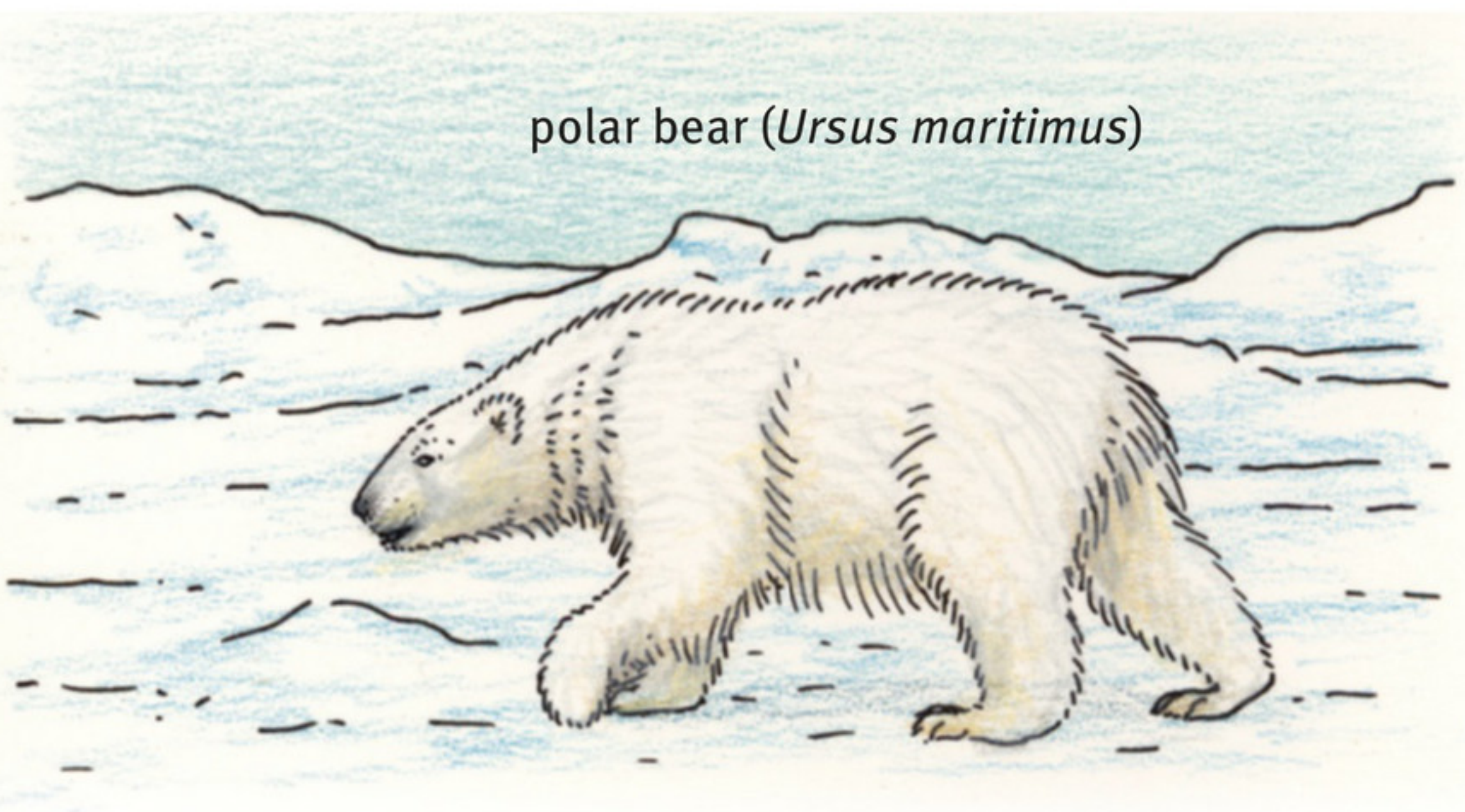
2 The area gets split into two by water.
The bears cannot reach each other anymore.



3 The environments on both sides of the water become more and more different from each other. Both groups of bears start adapting to their own area. This creates two new forms of the bear species.



grizzly bear (*Ursus arctos*)



polar bear (*Ursus maritimus*)

4 Over the course of a long time, two different species have been created.
The two bear species cannot have fertile offspring together.

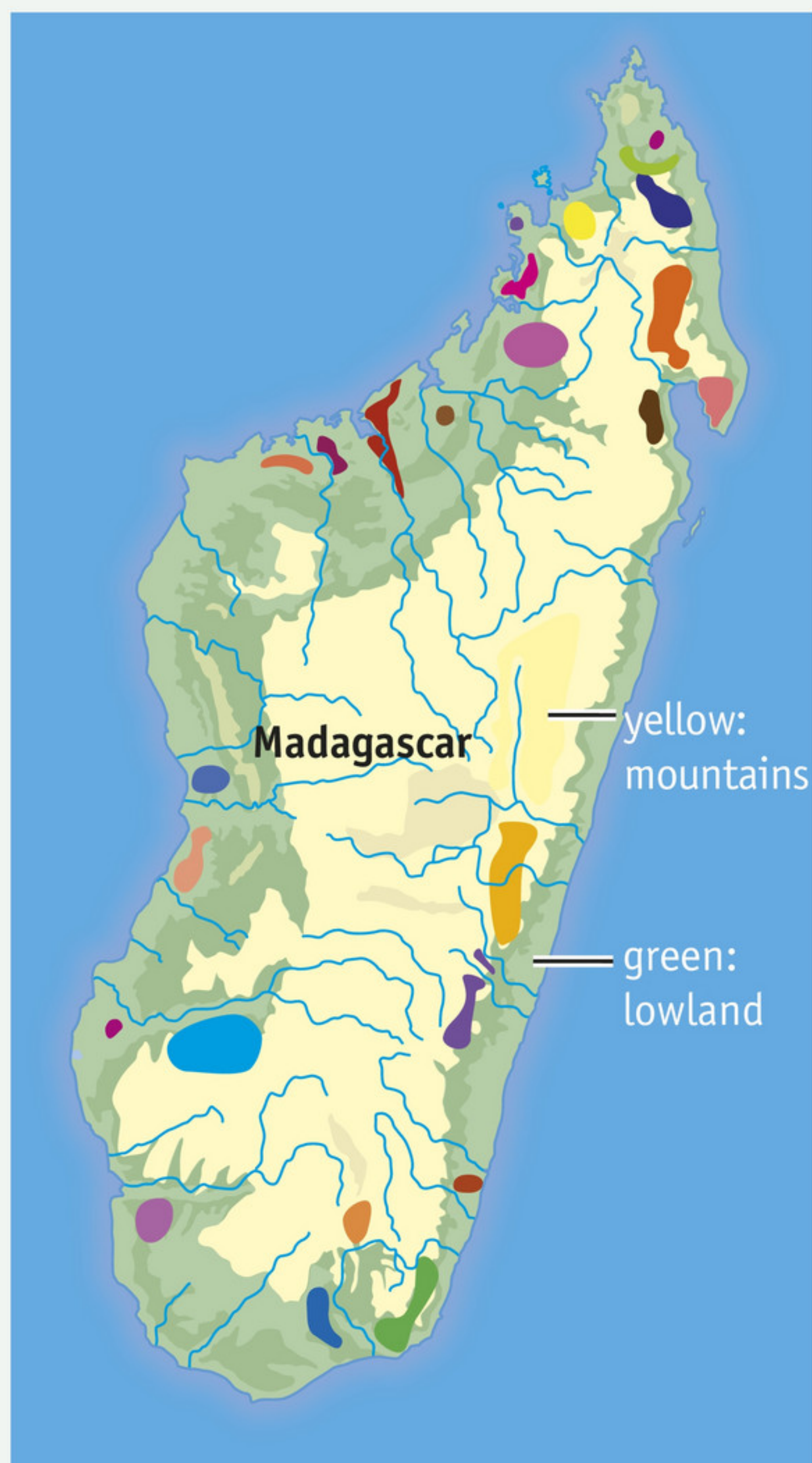
▼ Fig. 43

The lemurs of Madagascar

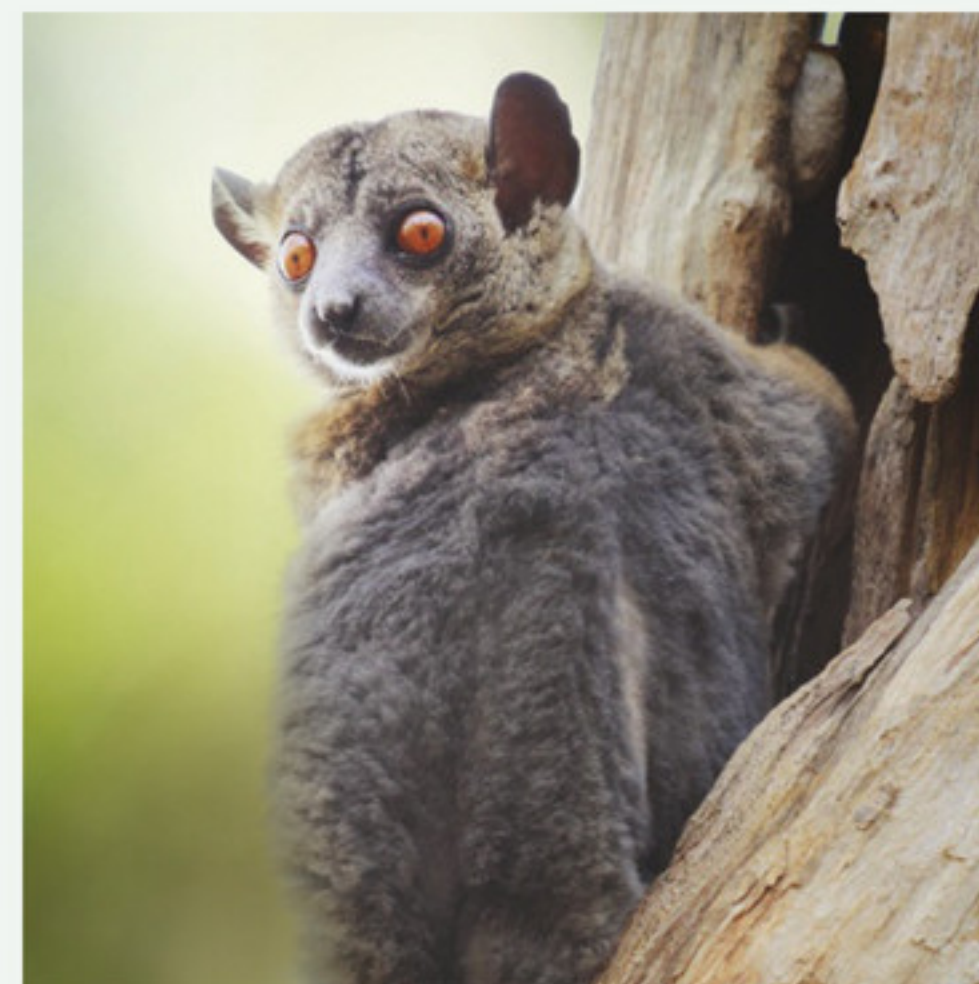
Long ago, Madagascar and Africa were connected together. A group of monkeys lived in this area. But because Madagascar separated from the African mainland millions of years ago, the monkeys of Madagascar were separated from the monkeys in Africa. Both groups adapted to their own environments. Over the course of time, the separated groups of monkeys became so different from each other that this resulted in new species.

Numerous monkey species have been created on Madagascar now as a result of isolation; they all belong to the lemur family. One example is the lepilemur genus. Lepilemurs are nocturnal animals that live in trees in the lowlands. They jump from tree to tree and rarely go down onto the ground. As a result, they do not cross rivers. The numerous rivers in the forests of Madagascar created what could be called 'forest islands' for the lepilemurs. About twenty species of lepilemur now live in Madagascar.

some of the lemurs of Madagascar



Distribution of the approximately twenty species of the lepilemur genus. Each species is indicated by a different colour.



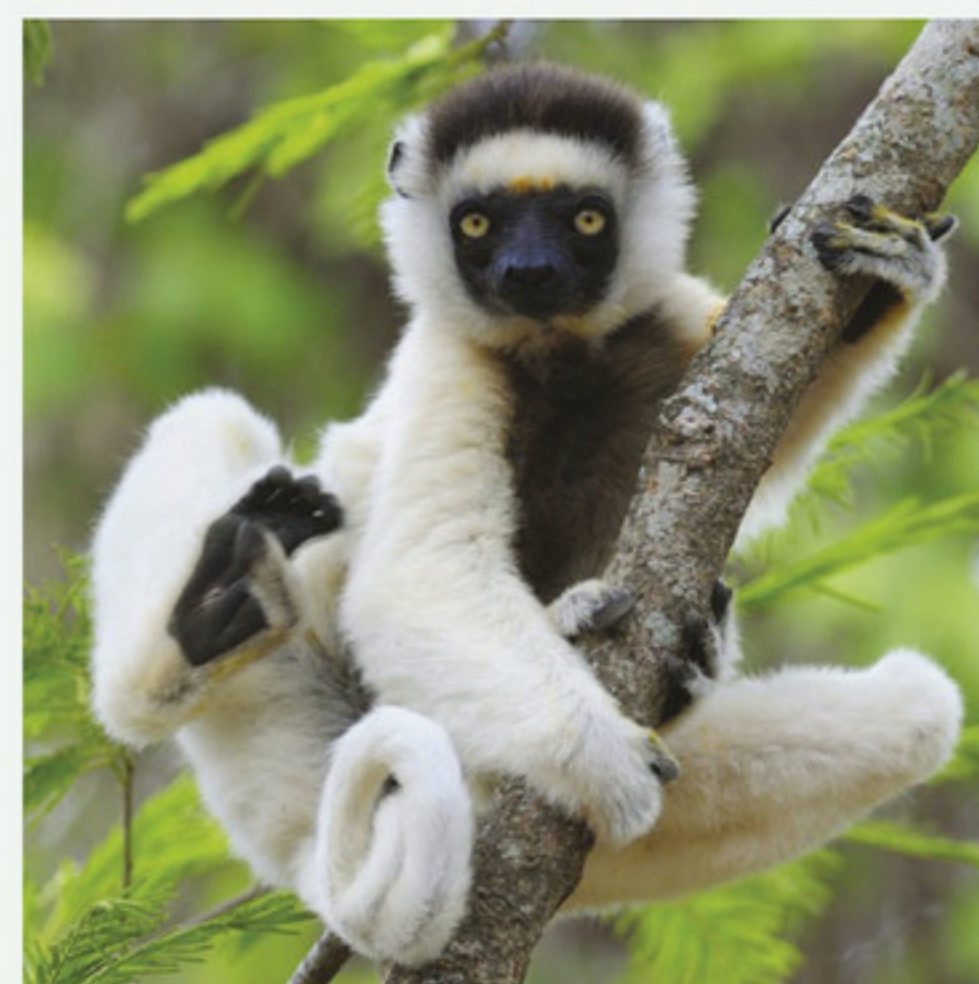
large lepilemur



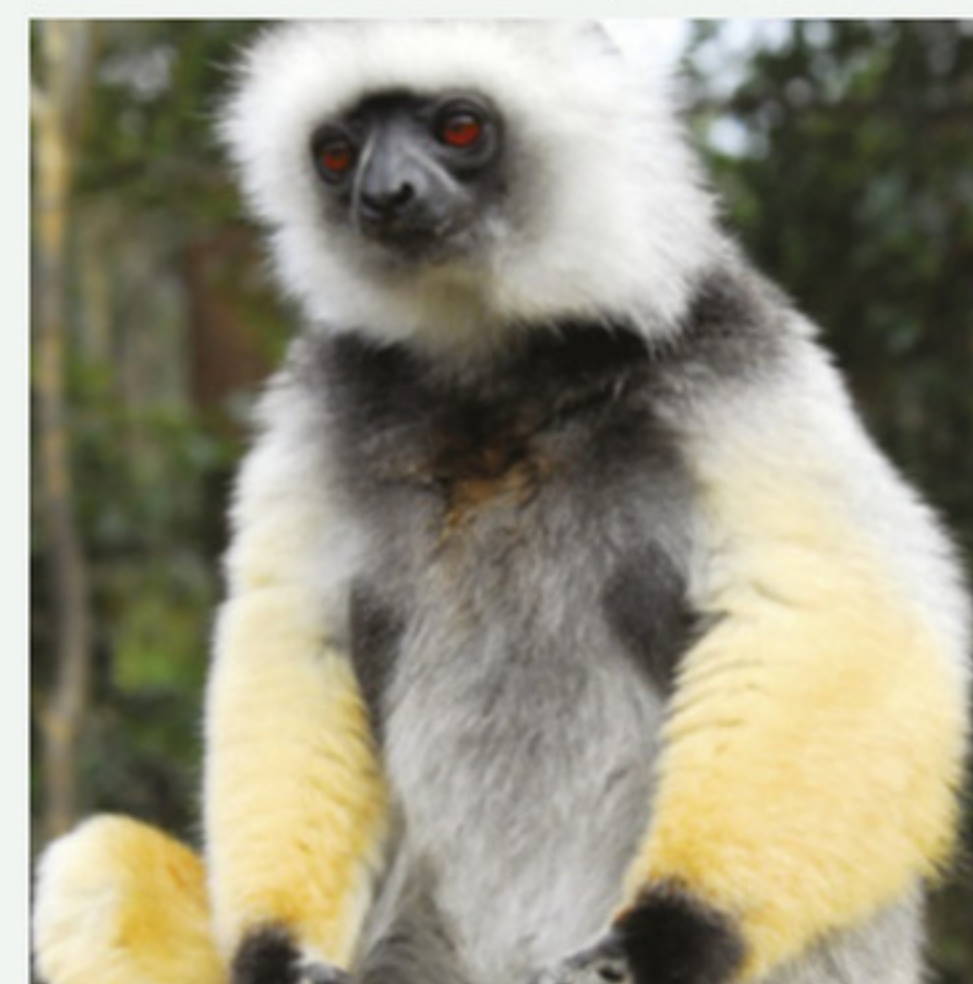
red-tailed lepilemur



crowned sifaka



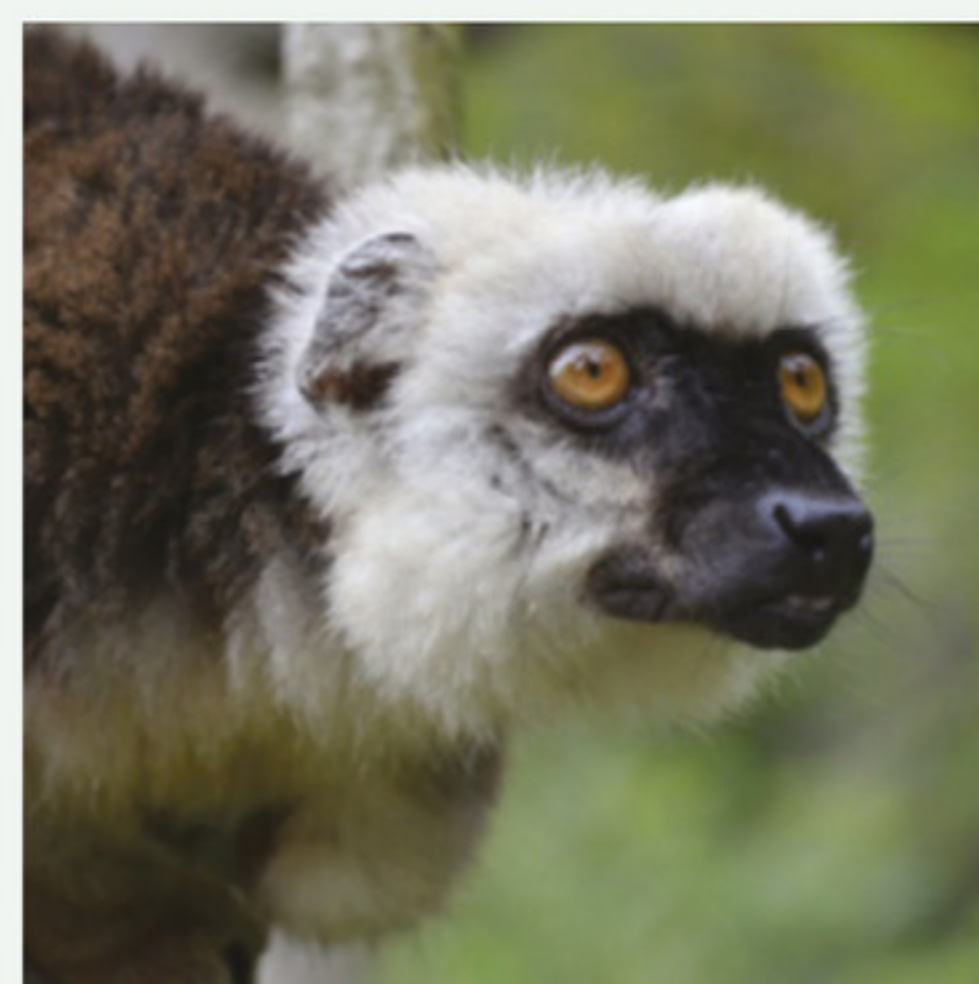
Verraux's sifaka



diademed sifaka



mouse lemur



white-fronted lemur



black and white ruffed lemur



red-ruffed lemur

6 Arguments for the theory of evolution

There are various arguments for the theory of evolution. Sometimes fossils are found in the layers of rock in the Earth's crust. These show that life on earth has developed over the course of time.

There are many similarities between different species, such as similarities in DNA, proteins and phenotypes. These arguments make the theory of evolution seem likely.

FOSSILS

Fossils are the mineralised remains of organisms, or traces of organisms preserved in stone (see figure 44). Figure 45 is a diagram showing how fossils are created. Fossils can only be created when remains of organisms do not rot away or decay. The remains can be covered by **sediments** (deposited layers of sand or clay particles, for example). If this happens quickly, bacteria and fungi do not have time to break down the remains entirely. If the sediments remain undisturbed, other layers will cover them. In the long run, the sediments mineralise into sedimentary rock because of the pressure of the layers on top of them.

► Fig. 44 Fossils.

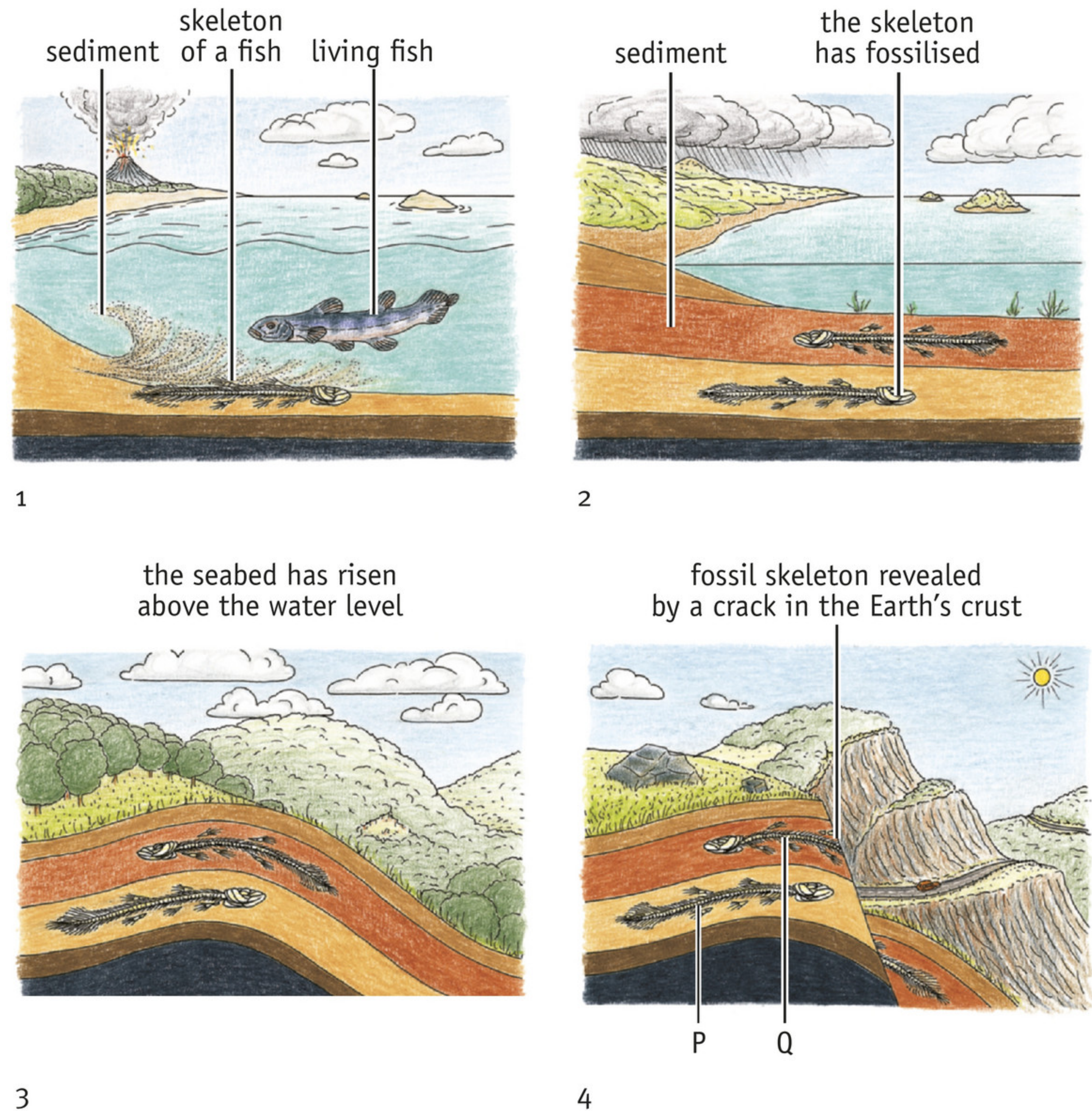


1 fossil bones of a dinosaur leg (with their discoverer)



2 fossil of an extinct reptile

► **Fig. 45** How fossils are formed (schematic).



▼ **Fig. 46**



1 fossil of a flying reptile with feathers (an ancestor of the birds)

2 reconstruction

Fossils of complete organisms are not often found. Only parts of organisms are usually found. Soft parts often decay too fast to **fossilise**. Fossils of shellfish are therefore found much more often than fossils of worms. People then use the fossilised parts to try and get a picture of what the organism once looked like. We call this a **reconstruction** (see figure 46).

New sediments are deposited on top of older layers. In general, the youngest rock layers are therefore found at the surface. Older rock layers are found deeper in the Earth's crust.

Fossils of some species of organisms are found in rock layers of different ages. But there are species where the fossils are only found in one rock layer and not in older or younger rock layers. These species of organisms probably only lived in a certain period, after which they died out. This shows that species appeared and disappeared throughout the history of the Earth. This is an important argument for the theory of evolution.

SIMILARITIES IN DNA, PROTEINS AND PHENOTYPES

Determining the DNA sequence of organisms is getting faster and cheaper. In part 1 you learned that the more similarities there are between the DNA of two species, the more closely these species are related. It is therefore logical that the proteins and (generally) the phenotypes of two closely related species will also show a lot of similarities. Research shows that this is true.

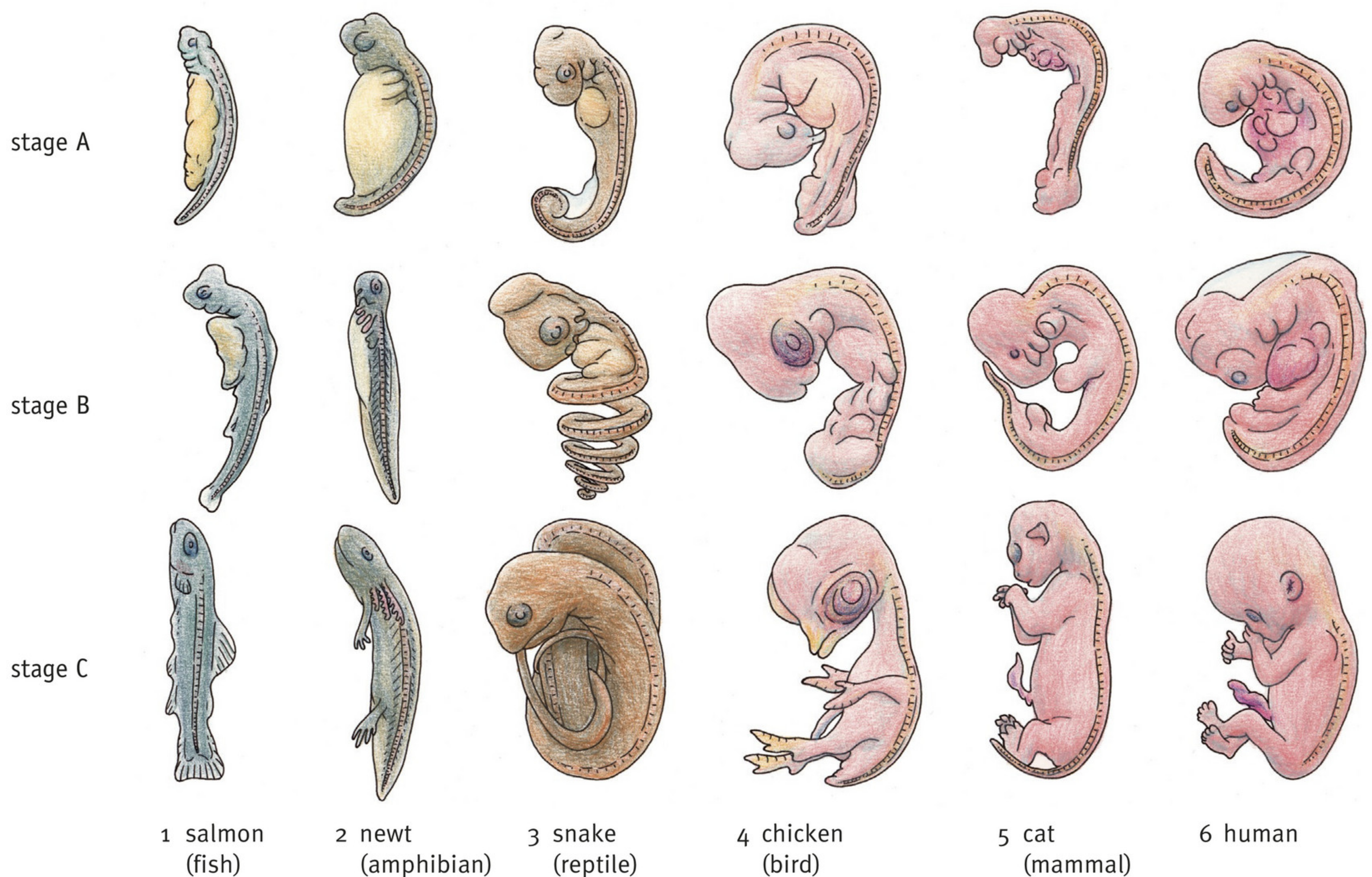
The more similarities there are in the DNA, proteins and phenotypes of two species, the more likely it is that these species have a common ancestor. Similarities in phenotype can for example be seen when you compare the embryonic development and the structure of organisms.

SIMILARITIES IN EMBRYONIC DEVELOPMENT

There are similarities in the embryonic development of various species. The embryos are very much alike at the start of their development in particular, but during their development the embryos start to become more different.

Figure 47 shows drawings of three stages from the embryonic development of five vertebrate animals and a human. The similarities in the early stages of embryonic development makes it likely that these vertebrates have a common ancestor.

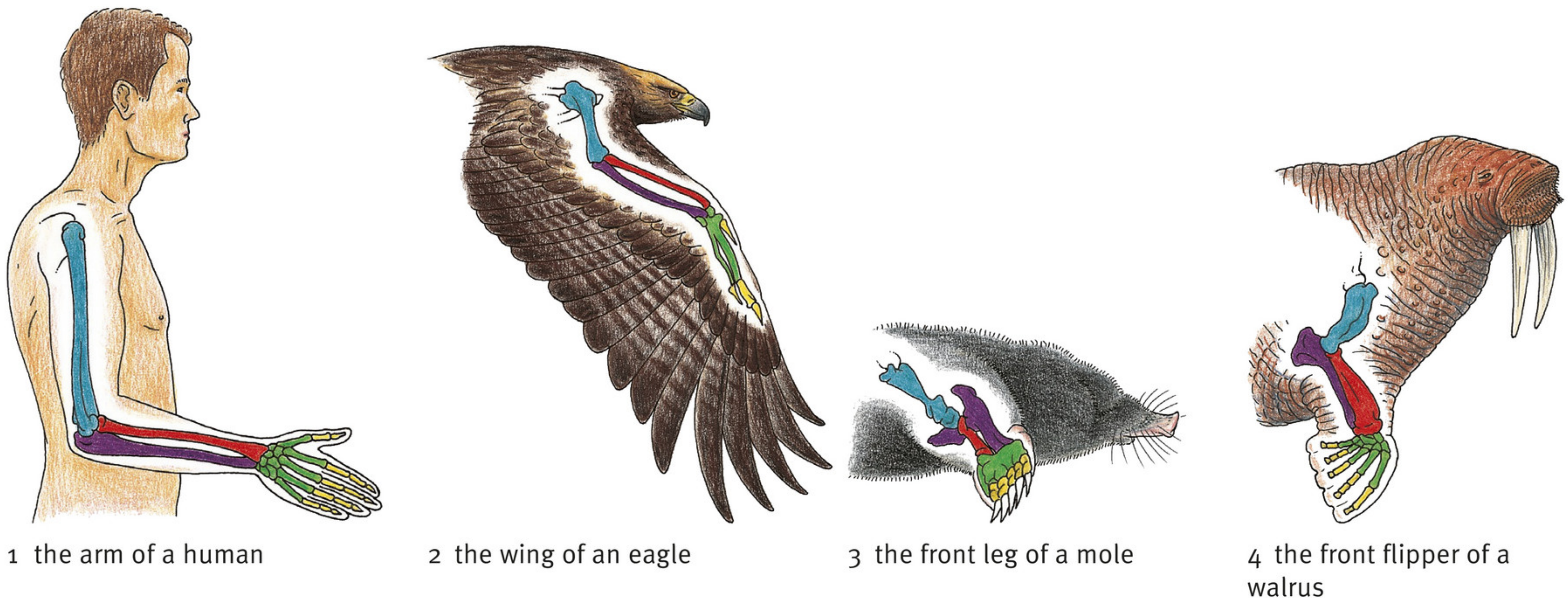
▼ **Fig. 47** Three stages in the embryonic development of vertebrates.



SIMILARITIES IN STRUCTURE

The arm of a human, the wing of an eagle, the front leg of a mole and the front flipper of a walrus have different functions. Figure 48 shows the skeletons of these organs, with corresponding bones in the same colours. You can see that these organs have similar structures. These organs are most probably derived from the same original structure. These animals therefore probably have a common ancestor. Adaptation to various environments has caused the organs to have different functions.

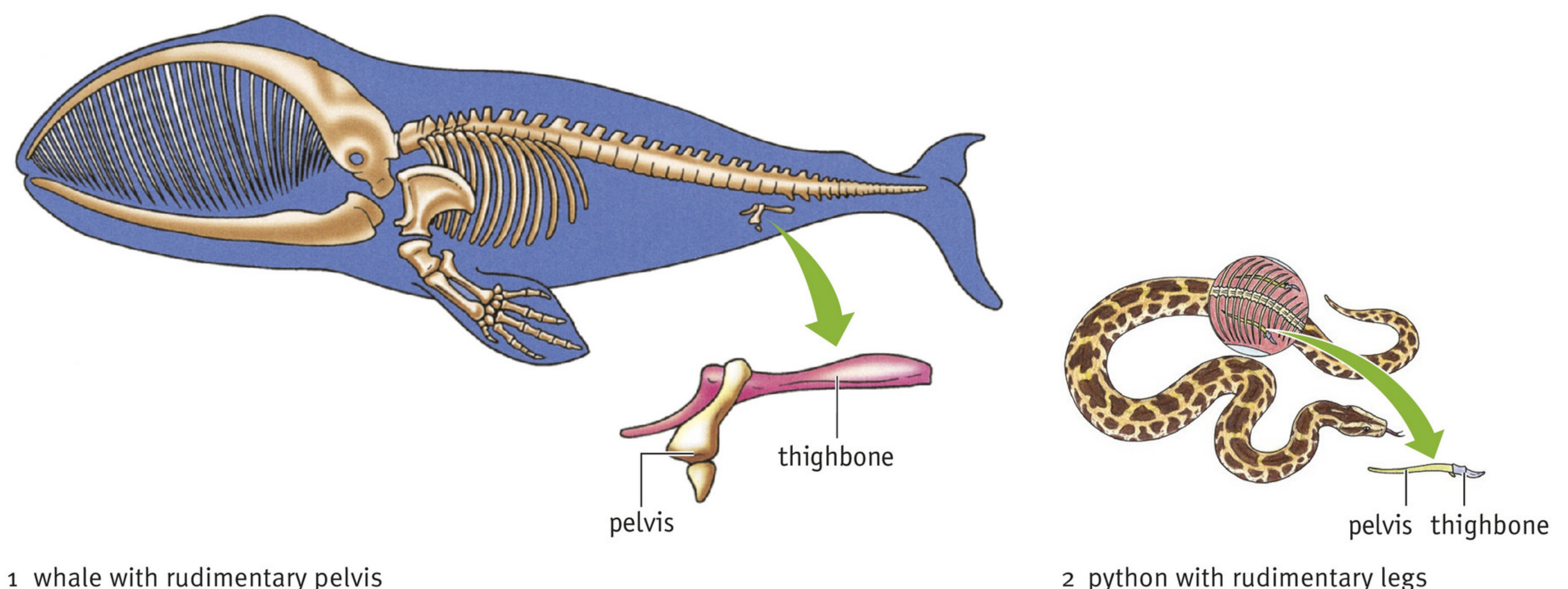
▼ Fig. 48 Arm skeletons.



RUDIMENTARY ORGANS

Certain organs can lose their function as a result of adaptation to the environment and they then do not develop, or hardly at all. These organs may disappear over the course of evolution. Examples are the hind legs of whales and the legs of snakes (see figure 49). Sometimes, a 'remnant' of these organs can be seen in an organism.

▼ Fig. 49 Rudimentary organs.



These are known as **rudimentary organs** or **rudiments**. Another name for them is vestigial organs. Four such rudiments in humans are shown in figure 50. Rudiments make it likely that different species of organisms have a common ancestor.

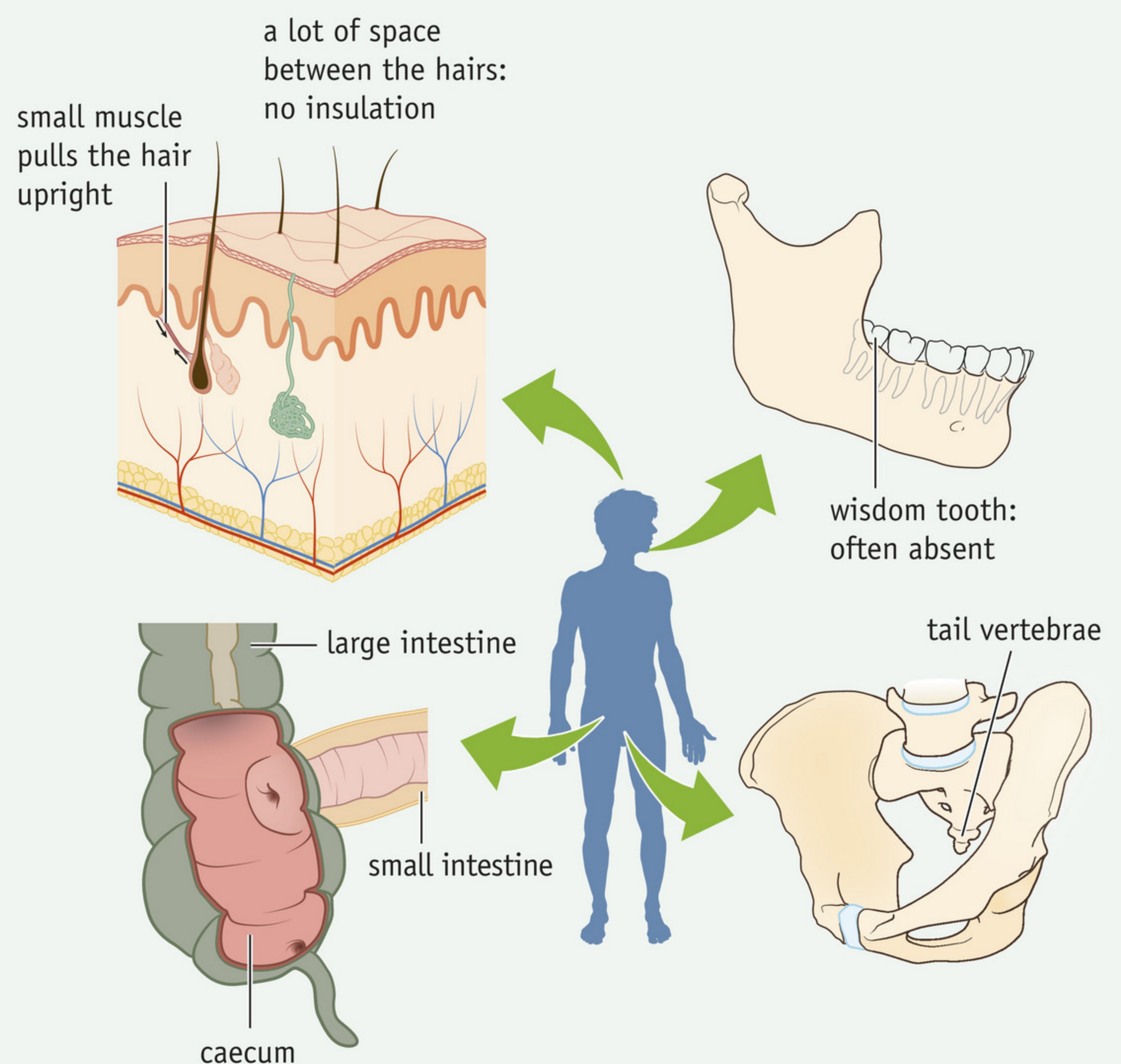
Similarities in processes such as **cell division** also make it likely that different species of organisms have a common ancestor.

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▼ Fig. 50

Rudiments in humans

The tail vertebrae and the caecum of humans are rudimentary (see the figure). The caecum is much longer in many herbivorous animals. The caecum of these animals has a function, helping digest plant food. The caecum of humans does not have this function anymore. In the past, wisdom teeth increased the chance of survival for our ancestors. It was because a large jaw and a lot of molars were very useful when eating food that was hard to digest and unprocessed. Today, our jaws are smaller and wisdom teeth are no longer needed. Goosebumps were enormously useful long ago, when our ancestors still had fur. But getting goosebumps hardly has any function for us today.



7 The history of life on Earth

We know a lot about the history of life on Earth through scientific research. This basics section will teach you more about the most important events. The history of life on Earth is subdivided into **eras**. The eras are further subdivided into **periods**.

Figure 52 shows the eras and periods on a **geological time scale** (geology = the study of the Earth). It shows how many millions of years ago each period started and ended. Various life forms have been drawn in the figure for each period of the geological time scale. The oldest life forms on Earth are at the bottom.

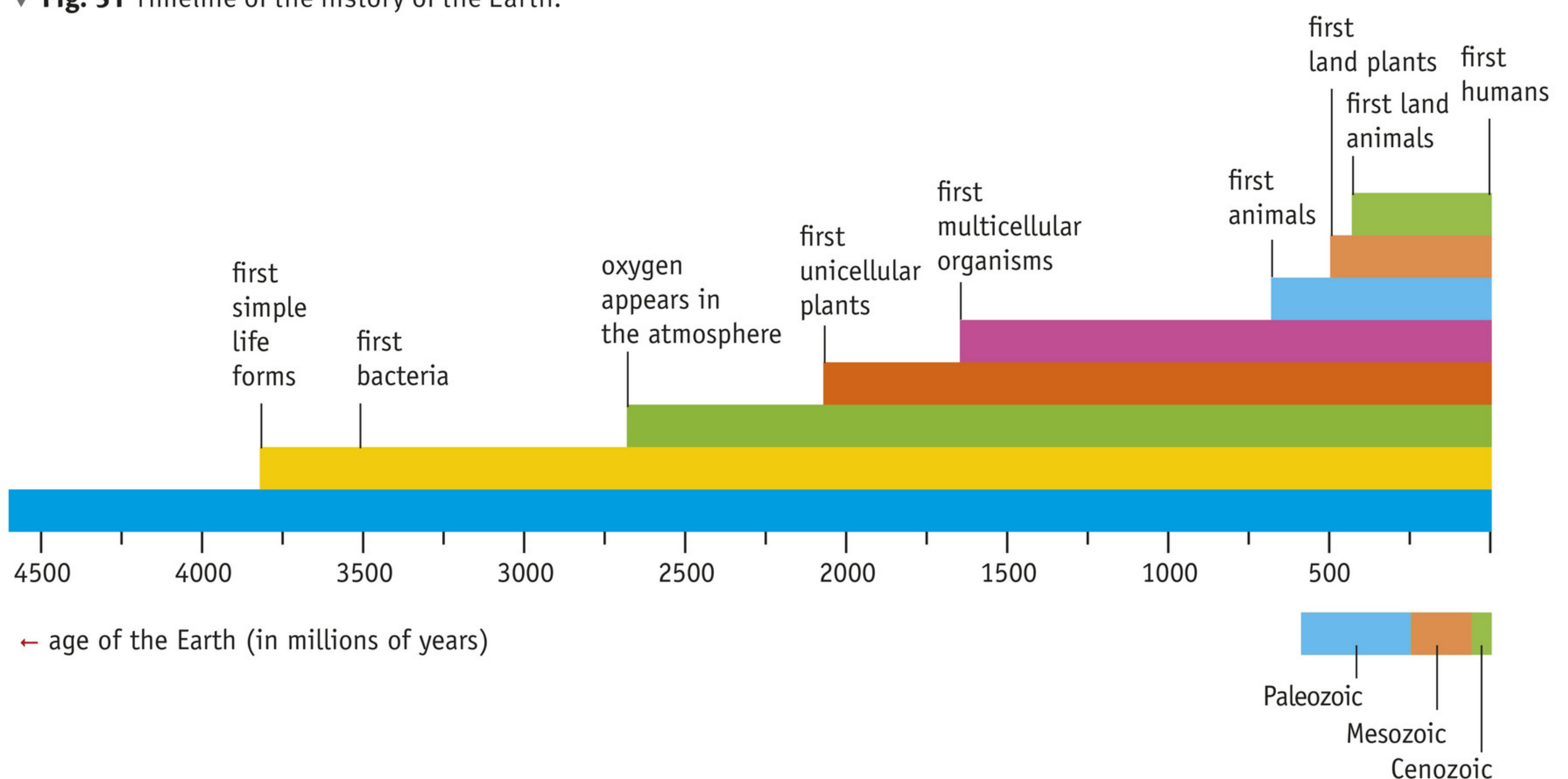
LIFE IN WATER

Figure 51 shows the history of the Earth on a timeline. The Earth is approximately 4600 million years old (4.6 billion years old). Life was not possible on Earth when it first existed. The temperatures were still too high then.

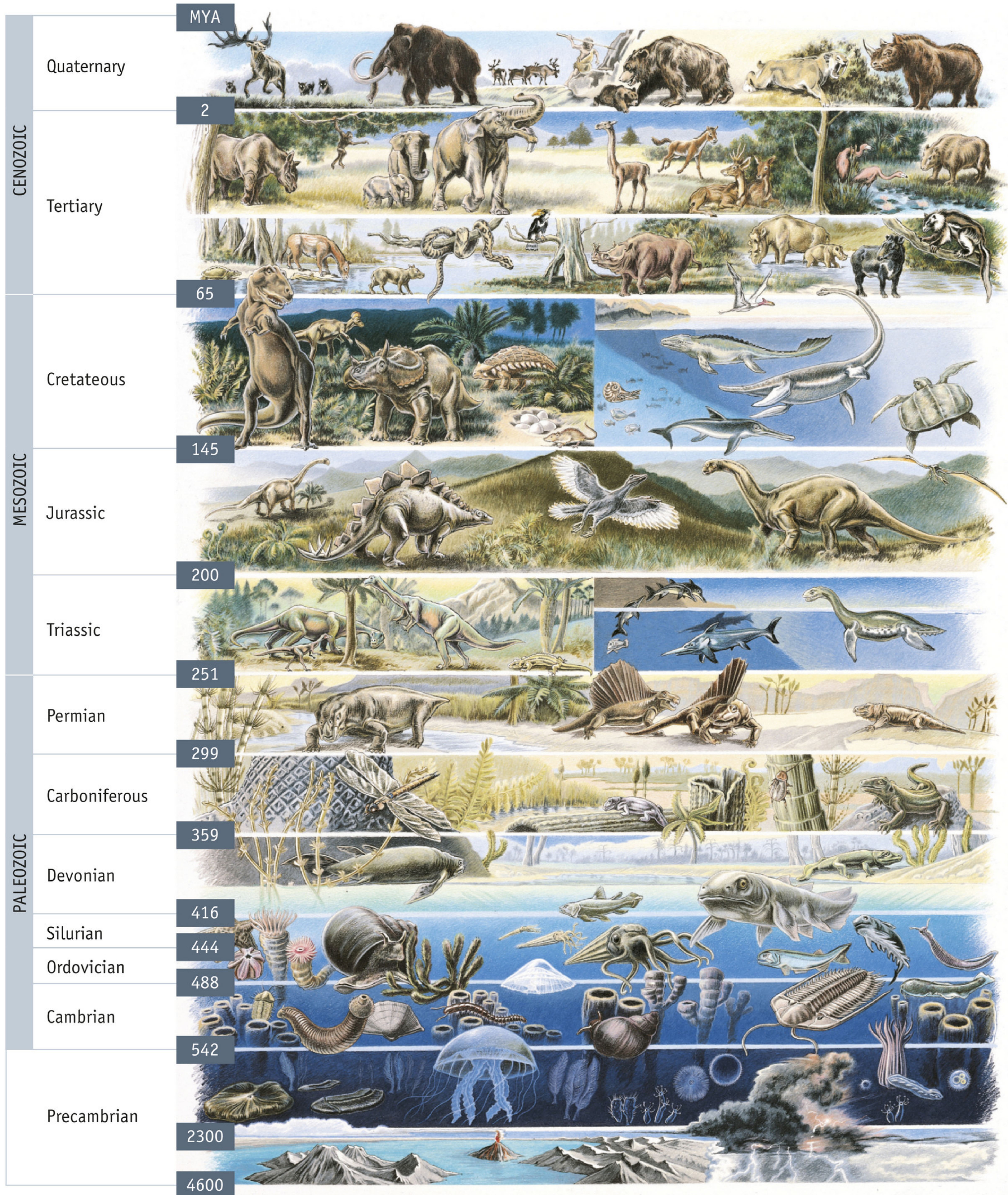
The **first simple life forms** probably appeared approximately 3800 million years ago. These first life forms lived in water. No fossils of organisms that lived on land have been found from that period. At the time, the air did not yet contain oxygen.

The first **bacteria** developed from the first simple life forms. Some of these bacteria were already able to produce oxygen. Approximately 3300 million years ago, other **unicellular organisms** emerged that could photosynthesise. As a result, more oxygen was released into the water and the air.

▼ **Fig. 51** Timeline of the history of the Earth.

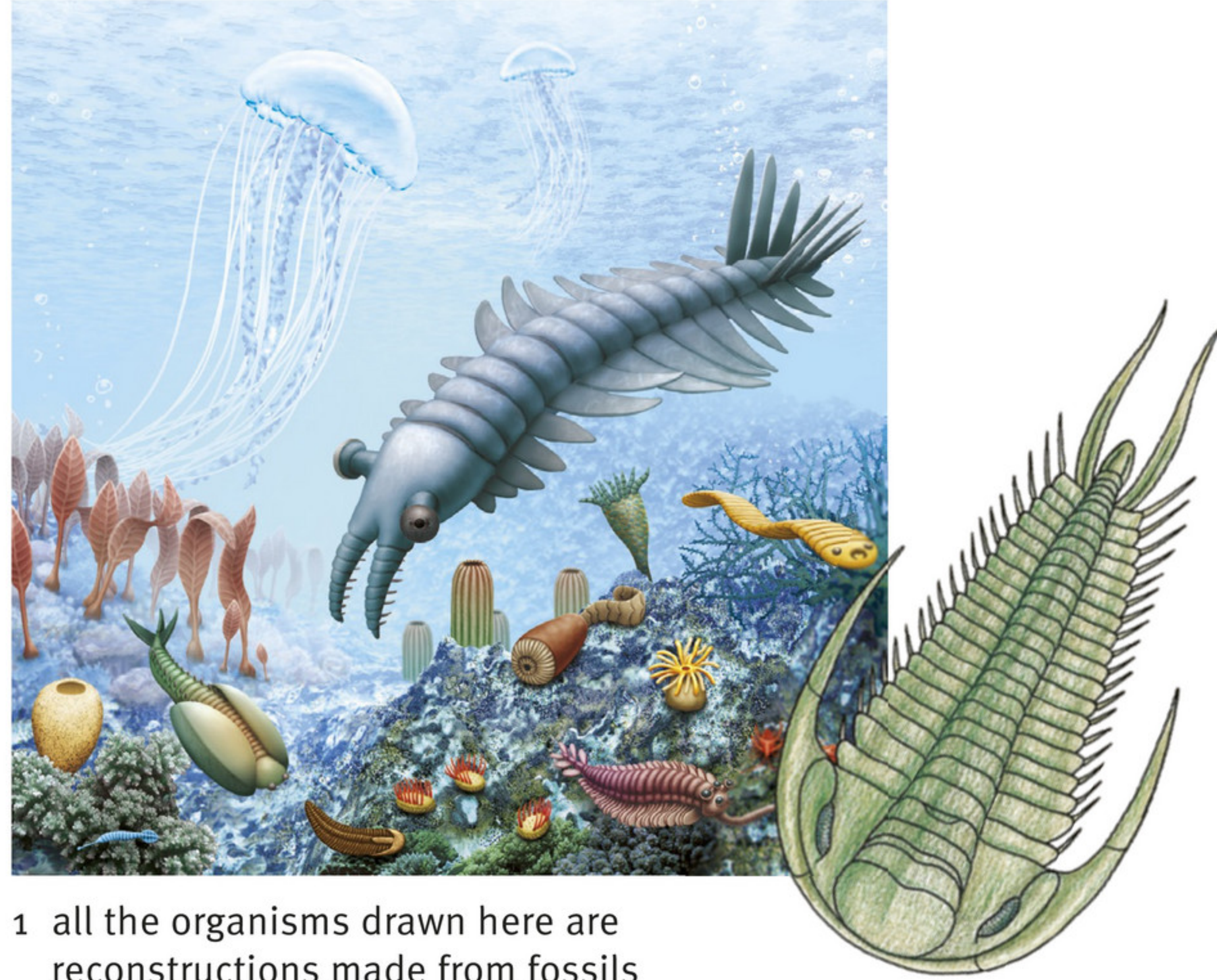


▼ Fig. 52 Geological time scale (MYA = millions of years ago).



Approximately 1600 million years ago, the first **multicellular organisms** developed from unicellular organisms. The first animals appeared about 700 million years ago. Sponges, cnidarians (such as jellyfish), flatworms, molluscs (such as squids), arthropods (trilobites, see figure 53.2) and echinoderms (such as starfish) were among the creatures that emerged. All these species appeared in the oceans and seas; only bacteria lived on land.

► **Fig. 53** Marine life.



1 all the organisms drawn here are reconstructions made from fossils

2 trilobite

▼ **Fig. 54** A forest in the Carboniferous period.



LIFE ON LAND

The first **land plants** (including mosses) appeared approximately 500 million years ago. The plants conquered the land and changed the barren plains (see figure 54). The first vertebrate animals, the **fish**, appeared in the same period. The first **land animals** appeared approximately 450 million years ago. The first land animals were mainly arthropods (centipedes in particular). They were soon followed by vertebrates – the **amphibians** and the **reptiles**. The heyday of the reptiles began approximately 251 million years ago. All kinds of lizard-like reptiles known as 'terrible lizards' or **dinosaurs** (*sauros* = lizard) appeared. Enormous dinosaurs lived on land (see figure 55). Some of them reached a length of more than 25 metres. All kinds of dinosaurs lived in water and in the air too. The first **mammals** and **birds** appeared alongside the dinosaurs.

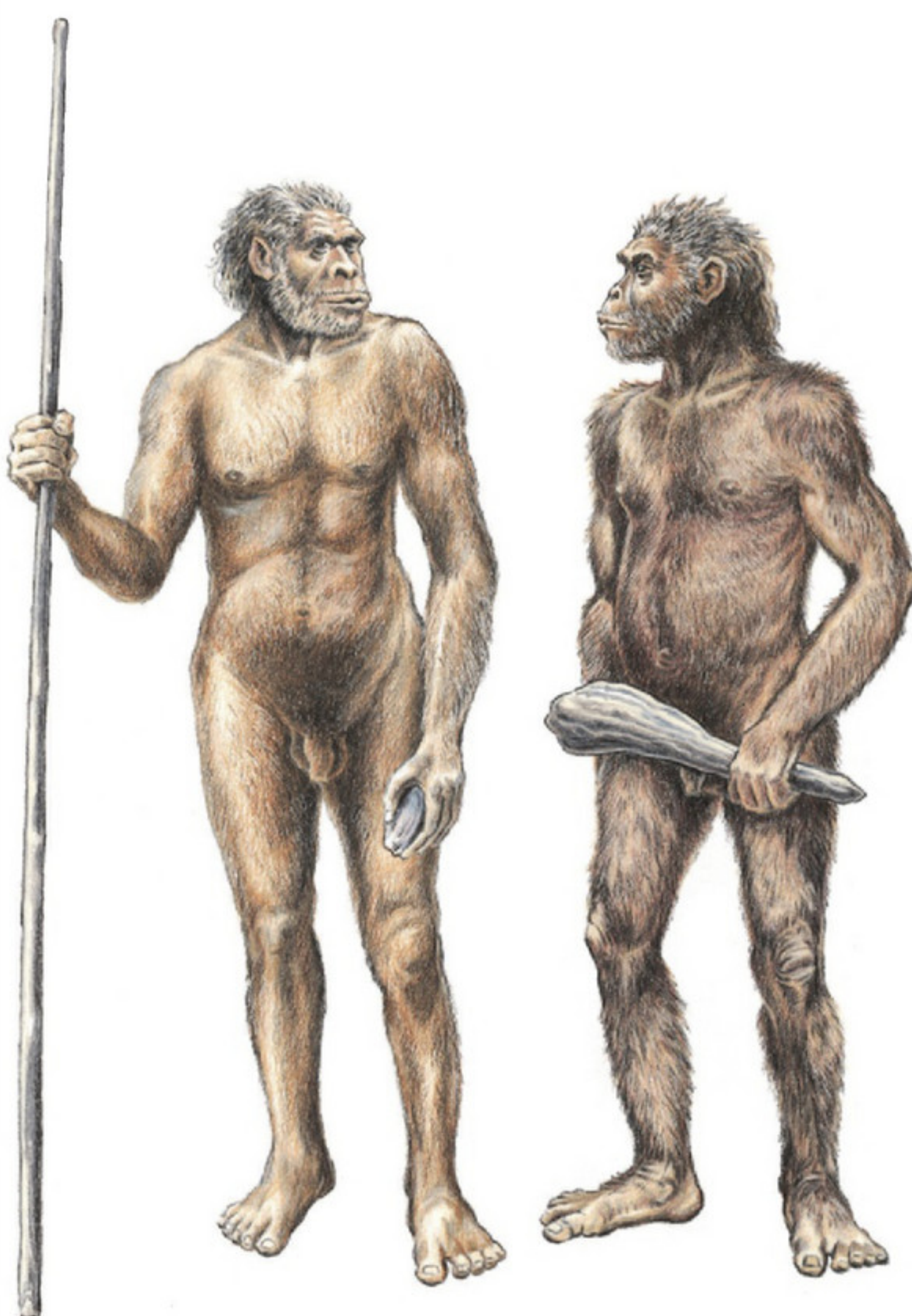
▼ Fig. 55 Extinct animals.



1 dinosaurs

2 bird and mammal

▼ Fig. 56 Hominids.

1 *Australopithecus africanus* 2 *Homo erectus*

Mammals and birds lived unobtrusively alongside the dinosaurs for millions of years. But the dinosaurs were wiped out within a short time 65 million years ago. This was caused by a rock with a diameter of approximately ten kilometres that hit the Earth from space. That created an enormous explosion, followed by massive forest fires. After that, black clouds of dust and soot hung over the Earth's surface for a number of years. These clouds probably blocked so much sunlight that they darkened almost the whole Earth, with temperatures dropping a long way as a result. The dinosaurs did not survive this climate change, but the mammals and birds did. After the black clouds had disappeared, the mammals and birds could flourish.

The first primitive **hominids** appeared approximately three million years ago (see figure 56). The human species that lives now (*Homo sapiens*) arose in Africa some 150,000 years ago.

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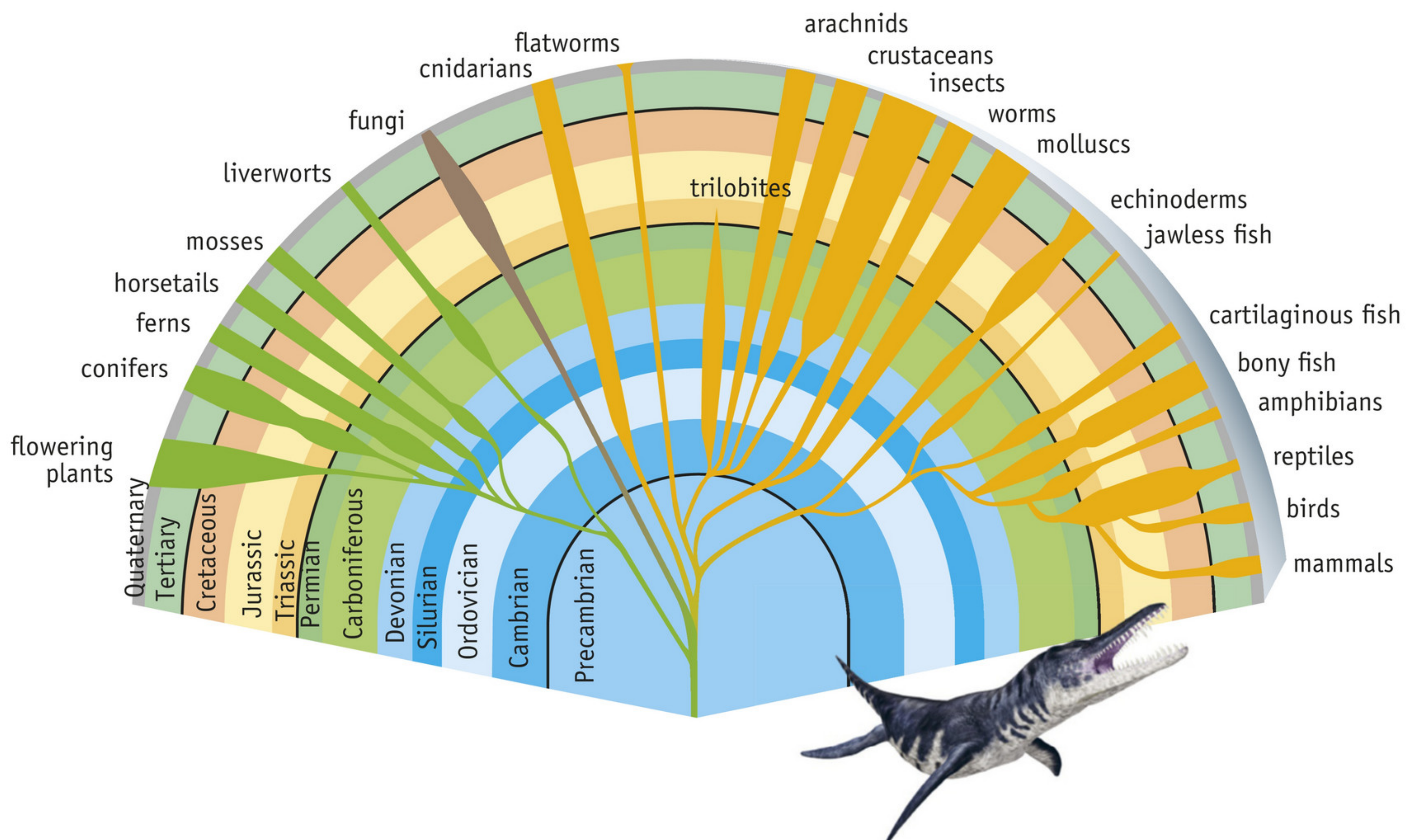
KINSHIP BETWEEN SPECIES

All kinds of species of organisms have appeared during the development of life on Earth. Species that have a common ancestor are related – they have a degree of **kinship**. In part 1, you learned that the longer ago the common ancestor of two species lived, the less closely related the species are.

Figure 57 is a schematic representation of the probable ancestry of organisms. This figure lets you read off which groups of organisms developed from others. It also shows you which groups have a close degree of kinship and which groups are less closely related. Finally, you can read off which groups were flourishing in which periods. These groups are drawn with a broader line then.

WB EXERCISES 24 AND 25, PAGE 29

▼ **Fig. 57** Probable branching tree of all organisms.



8 Biotechnology

▼ **Fig. 58** Baker's yeast.



Biotechnology is a collective name given to a variety of techniques whereby living organisms are used in the production of goods for humans. These techniques have been used for centuries, in particular for producing foodstuffs. Examples of such foods are bread, beer, wine, cheese, yoghurt and sauerkraut.

In part 1 you learned that fungi can be used for making foodstuffs. Bread, beer and wine are made using special fungi, the **yeasts**. When bread is made, yeasts make sure that the dough starts to rise. The dough becomes lighter and makes the bread less heavy on the stomach. During the production of beer and wine, yeast cells produce alcohol.

Cheese is produced using a substance from the stomach of new-born calves. When this substance is added to milk, it turns the milk into a solid mass that is then used to make cheese. Yoghurt is made from milk by adding certain types of **bacteria**. These bacteria form substances that give the yoghurt a sour taste. Sauerkraut is made from sliced white cabbage. Certain types of bacteria form substances that give the sauerkraut its sour taste.

Humans have used organisms for many centuries in the production of all these foodstuffs. Organisms have also been used for a very long time to produce certain flavourings, medicines and hormones. The organisms used are able to produce the required substances by themselves. The genotypes of the organisms do not have to be changed for this.

► **Fig. 59** Foodstuffs where biotechnology has been used for centuries.



GENETIC MODIFICATION

Biotechnology has become more and more important over the past few years. This is because of the development of techniques for inserting new hereditary information into the DNA of an organism. This could be information from another species of organism, for example. These techniques are known as **recombinant DNA technology**. An example of such a technique is given below.

In part 1 you learned that diabetes patients have to inject themselves with a certain amount of insulin every day. Until recently, insulin was a very expensive drug. It was extracted from the pancreases of slaughtered pigs. This method took a lot of time and was expensive. Healthy people have a gene that contains the information for producing insulin. Bacteria do not have this gene. DNA with this gene was removed from human cells and inserted into certain bacteria. These bacteria then have the information for producing insulin and they do indeed start to produce it. Culturing these bacteria on a large scale makes it possible to produce pure insulin cheaply.

▼ **Fig. 60** Examples of genetic modification.



Goats produce medicine

The American company GTC Therapeutics is the first company to be given permission to market a particular new medicine in Europe. The medicine Atryn is extracted from the milk of genetically modified goats. Atryn reduces the risk of blood clotting after surgery or childbirth in patients with a rare hereditary blood condition.



More juice from fruit

The enzyme pectinase is used in the production of fruit juice. This enzyme is produced by a genetically modified fungus. Pectinase breaks down part of the cell walls in fruits, which gives a higher juice yield.



Apple trees without scab

Researchers in Wageningen have inserted a gene from barley into the genotype of apple trees. The gene from barley contains the information for producing a substance that protects against fungi. The genetically modified apple trees are now much more resistant to damage due to scab, meaning that less pesticide is needed.



Stonewashed jeans

In the past, jeans were washed in a large washing machine with pumice stones to give them a stonewashed look. It cost a lot of energy and a lot of time. Today, this is done much more cheaply and quickly by treating them with the enzyme cellulase, which is produced by genetically modified bacteria.

▼ **Fig. 61** Some foodstuffs contain genetically modified maize.



All kinds of required hereditary characteristics can be 'inserted' in organisms using recombinant DNA techniques. This is known as **genetic modification**. Genetically modified organisms are referred to as **transgenic**.

As well as microorganisms, plants and animals are also often modified genetically. You can see a number of examples of this in figure 60. Genetically modified organisms are used in healthcare, agriculture, industry and the environment. Most applications are in food production (see figure 61).

Some people support genetic modification because it increases food production levels. This is necessary in order to provide the ever-growing world population with food. Genetic modification makes it possible to produce some crops in a more environmentally friendly way and to treat some diseases better (see figure 61).

But there are also people who do not agree with genetic modification. They think, for example, that humans do not have the right to change the hereditary characteristics of organisms however they see fit. Or they reject the idea of randomly 'creating' all kinds of new organisms using genetic modification. They are also afraid that organisms that were genetically modified will end up in nature and cause damage there.

WB EXERCISE 26, PAGE 33

► **Fig. 62** Genetic modification.

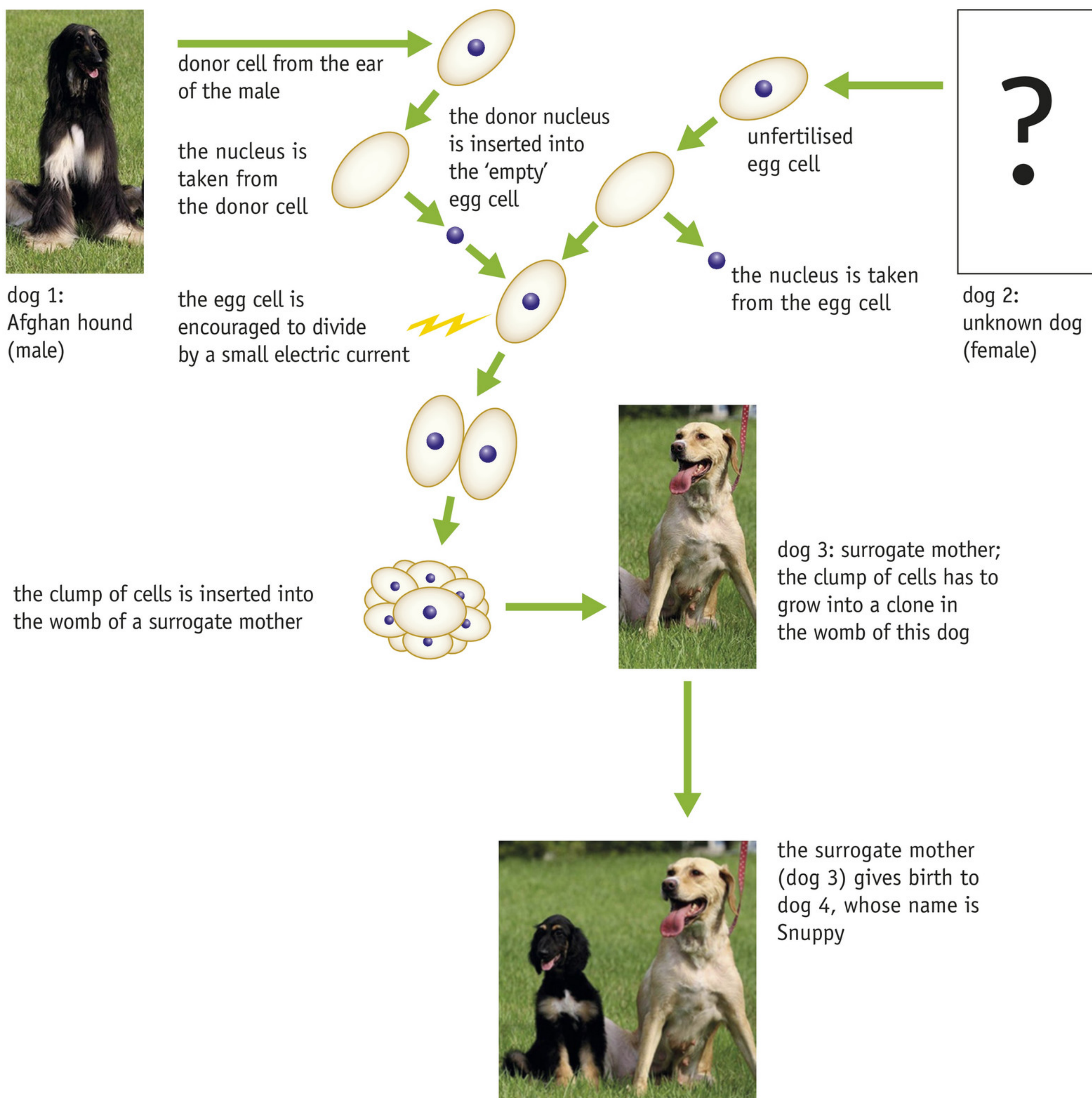


CLONING

Cloning is an artificial way of reproducing organisms, resulting in offspring that all have the same genotype as the cloned organism. Cloning is a form of asexual reproduction. Cloning in plants has been used for much longer than cloning in animals. Clones of a plant can be made by taking cuttings or by propagating plants using bulbs, tubers or roots.

Animals can be cloned by **nuclear transfer**, for example. To do this, the nucleus of a body cell is transplanted into an egg cell after the egg cell's own nucleus has first been removed. A clump of cells develops from the egg cell: this clump of cells can be inserted into the womb of a **surrogate mother** and can grow into a new organism (see figure 63). Making clones using this technique is still difficult.

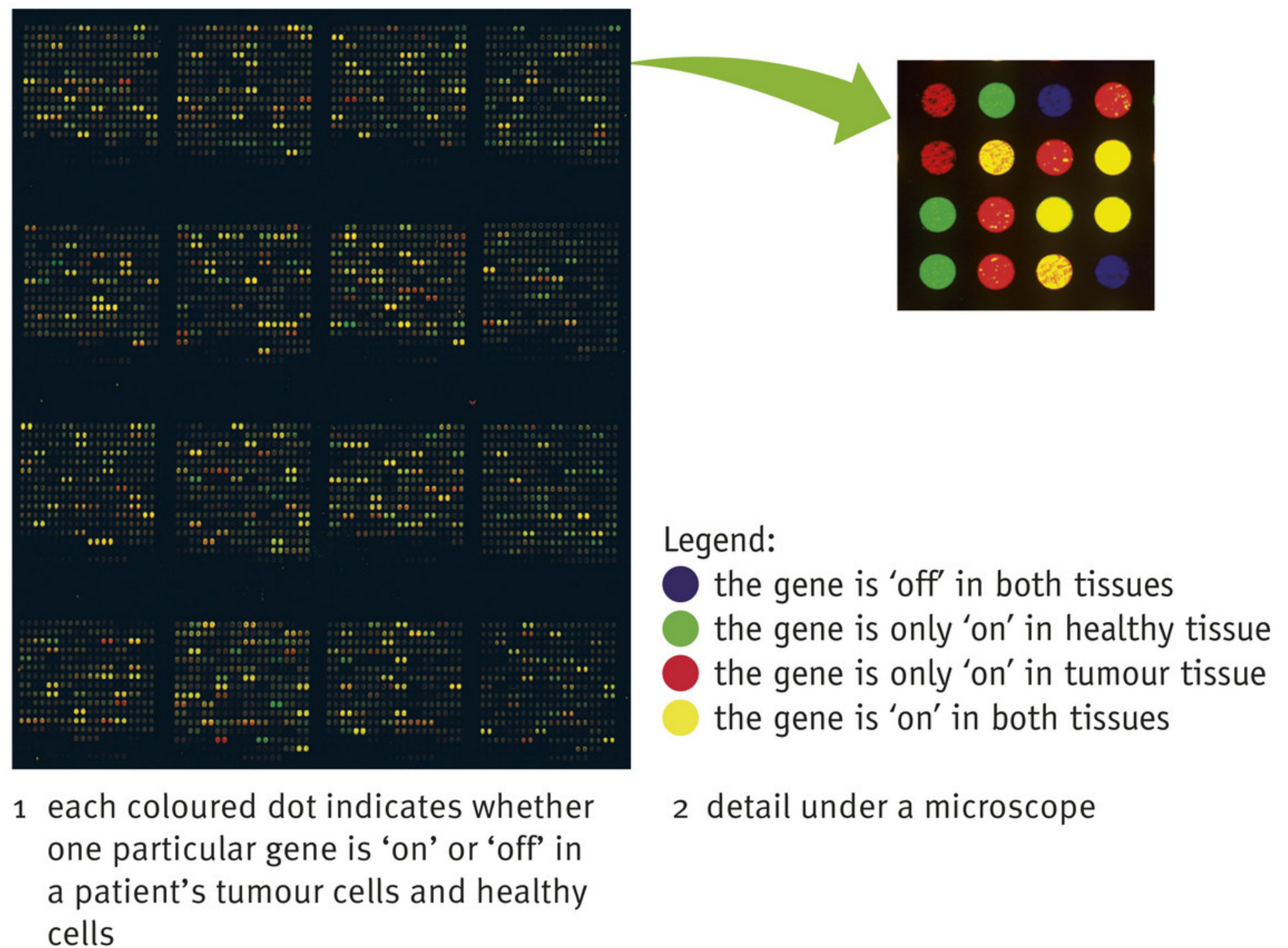
▼ Fig. 63



GENOMICS

Genomics is the study of the entire DNA of an organism (or a large part of the DNA) along with all the genes it contains. Genomics is used in cancer research, for example. In figure 29, you read that Martin compares a lot of genes at the same time in cancer research. In cancer research, researchers also study the activity of a lot of genes at the same time. The researcher compares the activity of genes in healthy tissue and in tumour tissue. A special technique lets them see which genes are *on* and which genes are *off* in tumour tissue and healthy tissue (see figure 64). In the livestock farming sector, genomics is used to select favourable genotypes for breeding bulls (see figure 65).

► **Fig. 64** Genomics in cancer research.



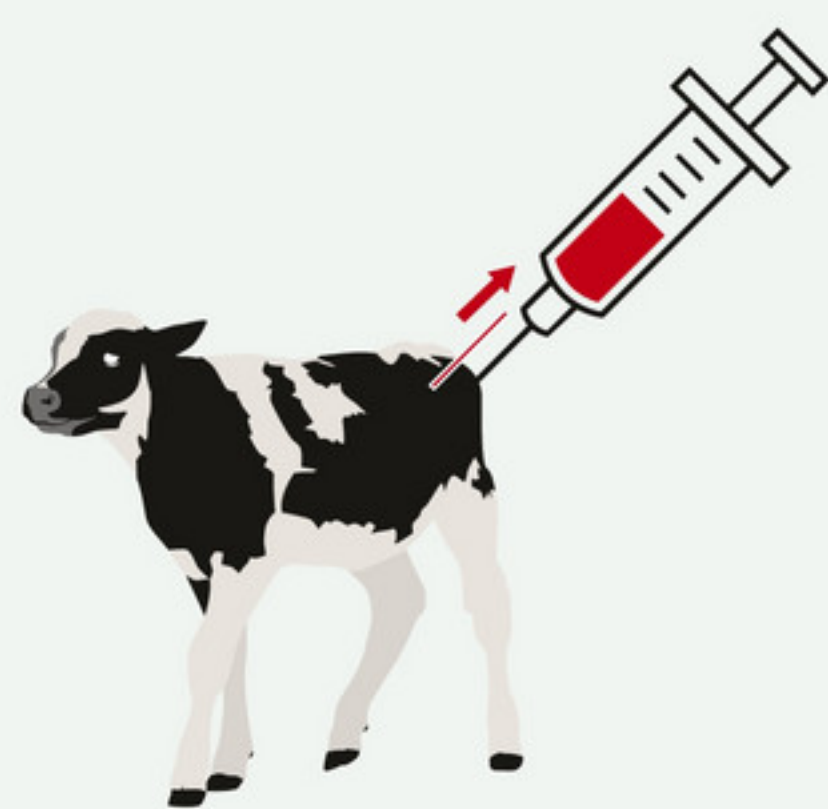
▼ Fig. 65

Genomic selection in the livestock sector

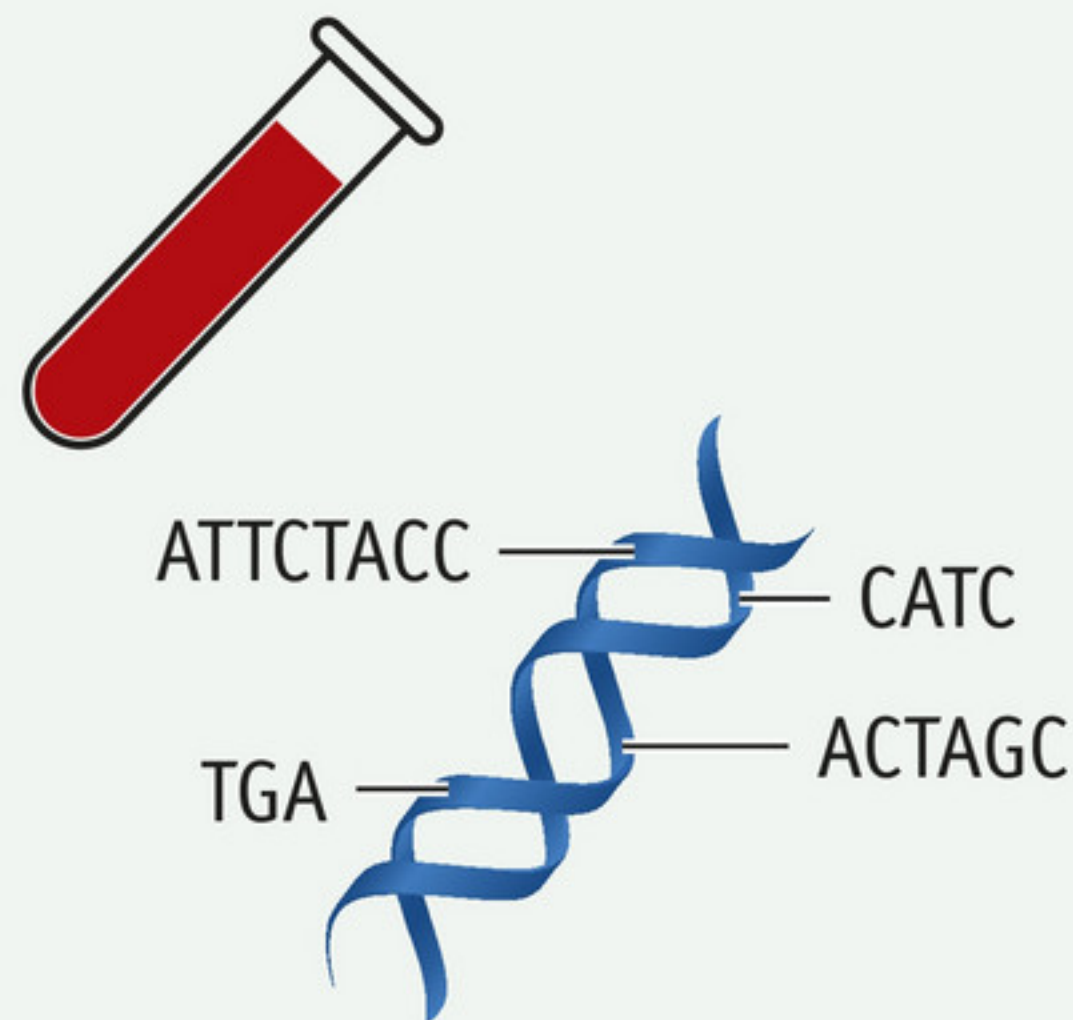
Until recently, it took five years or more to determine whether a bull was a so-called elite bull with good characteristics for the offspring. If you used the old way, you just had to wait and see. After all, it was only possible to tell after five years (and if the bull had sufficient offspring) whether the offspring really had the desired characteristics, such as a high annual milk yield. This could also go wrong.

Genomic selection for breeding bulls speeds up this process. For many alleles, it is now known what

predictive value they have for the offspring. A certain allele, for example, is a predictor of a higher milk yield of twenty kilograms a year. It turns out that the milk yield is determined by a lot of genes. DNA tests make it possible to look at a lot of bull calves and determine which has the best combination of alleles to make sure that its offspring have a high milk yield. This genomically selected elite bull can then already be used as a breeding bull from the age of twelve months, once it is sexually mature.



1 a blood sample is taken from a group of calves that are expected to have a favourable genotype



2 DNA tests determine the predictive value of a series of alleles for the offspring of each calf



3 software is used to select calves with the most favourable genotype to be breeding bulls

DNA TESTING

DNA tests are becoming cheaper, faster and more and more accurate. That is why DNA tests are becoming increasingly important in the fight against crime, for example. Each one of us has their own unique DNA. If skin flakes, hair, sperm or blood traces are found at the scene of a crime, the DNA from the cells can be examined. Figure 66 shows you how this works. This can allow the real perpetrator to be unmasked from among a group of suspects. DNA tests can be used in many fields, for example to trace fraud with meat (see figure 67). Genomics can be used for DNA tests.

Genetic disorders can also be detected using DNA tests. Furthermore, DNA tests can show evolutionary kinship between species, or show that a new species has been found. Figure 10 tells you how a DNA kinship test can be used to test whether a man is the biological father of a certain child.

WB EXERCISES 27 AND 28, PAGE 33

▼ **Fig. 66**

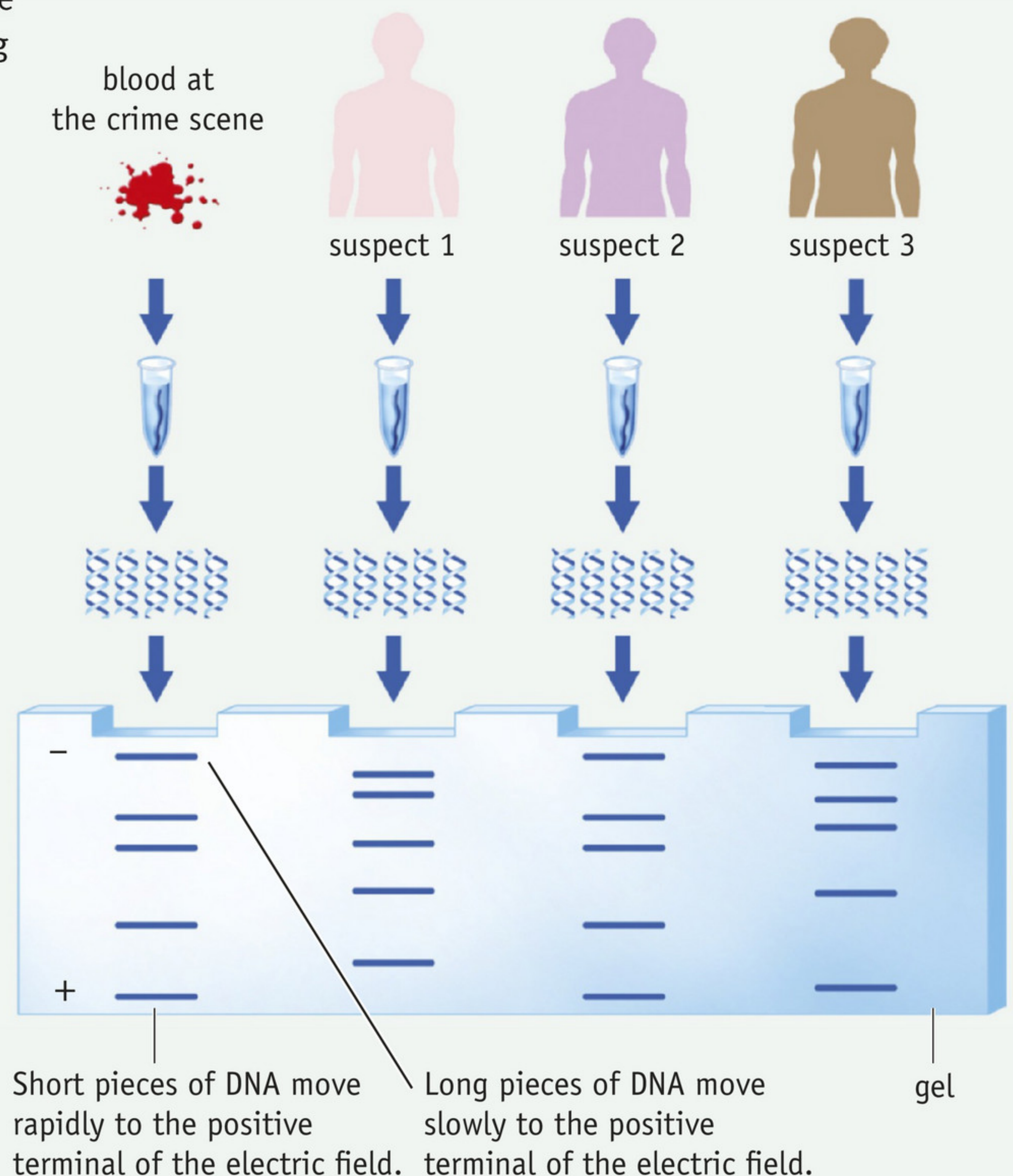
Disco killer identified by DNA test

A life sentence has been demanded for a 52-year-old man. He is suspected of having killed five women in the 1980s. The suspect was called the 'disco killer' because he picked up victims who were hitchhiking after visiting a disco. The man was identified eighteen years later in a DNA test that he had to take after being caught in a burglary. The DNA of the 52-year-old man turned out to match the DNA traces that were found at the scene of the murders in the 1980s.

DNA is extracted from body cells.

The DNA is cut into pieces by enzymes. The resulting mix of short and long pieces of DNA is unique for each person.

The pieces of DNA are placed in a gel with an electric field across it. A DNA pattern is created after a while that is unique for every human.



▼ **Fig. 67**

Horse meat fraud uncovered by DNA test

A DNA test makes it possible to find out the origin of meat and therefore detect any fraud. One example is fraud in which cheap horse meat is sold as expensive beef. The figure shows a particular DNA sequence for humans and the same DNA sequence from four animals

that are widely eaten. A dot in the figure indicates that the same building block (C, G, A or T) is found at that position as in humans. This DNA sequence can be used to find out the origin of the meat.

HUMAN	TTCGGCTCACTCCTTGGCGCCTGCCTGATCCTCCAAATCACCACAGGACTATTCCCTAGCCATG
COW	 T G . . AAT A A T C A . . A
PIG	 T A . . AT A . . T . G TA C . . G A . . A
HORSE	 A . . AAT A TTA C T A
CHICKEN	 A . . A . GA . T C . . GAC T . . . C . . C . . C . A

9 Dominant and recessive alleles

You have learned that an allele pair may have two identical alleles or two non-identical alleles for a given hereditary characteristic. Figure 15 has already shown you that humans may have an identical allele pair for the hair type, for example two alleles for straight hair or two alleles for curly hair. An organism with an identical allele pair for a given hereditary characteristic is said to be **homozygous** for this characteristic (homo = the same). A person may have a non-identical allele pair for a certain characteristic, for example a non-identical allele pair for the hair type: one allele for curly hair and one allele for straight hair. An organism with a non-identical allele pair for a given characteristic is said to be **heterozygous** for this characteristic (hetero = different). People can therefore be homozygous or heterozygous for the hair type (see figure 68).

▼ Fig. 68



1 homozygous for straight hair



2 homozygous for curly hair



3 heterozygous for hair type

Legend:

-  allele for straight hair
-  allele for curly hair

People who are heterozygous for their hair type have the allele for straight hair as well as the allele for curly hair. These people turn out to have curly hair. Only one of the two alleles is expressed in the phenotype. We call this the **dominant allele**. The other is called the **recessive allele**. This allele is not expressed in the phenotype if there is a dominant allele in the other chromosome of the pair of chromosomes. The dominant allele is 'stronger' than the recessive allele, as it were.

The colour of the hide of cattle can be brown or black (see figure 69). If it is known that the black bull is heterozygous for hide colour, then you know that the allele for black hide is dominant. After all, the bull has both the black and brown alleles for hide colour, but the phenotype is a black hide. Only the allele for a black hide is expressed in the phenotype: the black allele is therefore dominant.

This also tells you that the brown bull is homozygous for hide colour, because if that bull had one dominant black allele, its hide would have been black. Knowing that the brown hide colour is recessive would be enough to tell you that the brown bull is homozygous for hide colour. You do not know this for the black bull: it could be homozygous or heterozygous for hide colour.

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► Fig. 69



1 black hide – homozygous or heterozygous?



2 'red' hide – homozygous

GENE SYMBOLS

Alleles are indicated by letters. One letter is used for a single hereditary characteristic. A dominant allele is indicated by a capital letter, a recessive allele by a lower case letter.

For example, a person who is homozygous for curly hair (dominant) is indicated by AA, a person who is homozygous for straight hair (recessive) is indicated by aa, and a person who is heterozygous for hair type is indicated by Aa. You can also use a different letter, BB, bb and Bb for example. The best thing to do is to always use letters where the capital and lowercase letters are clearly different (not P and p, for example – R and r are better).

WB EXERCISE 30, PAGE 36

10 Genetic testing

▼ **Fig. 70** Breast examination.



▼ **Fig. 71** Ultrasound.

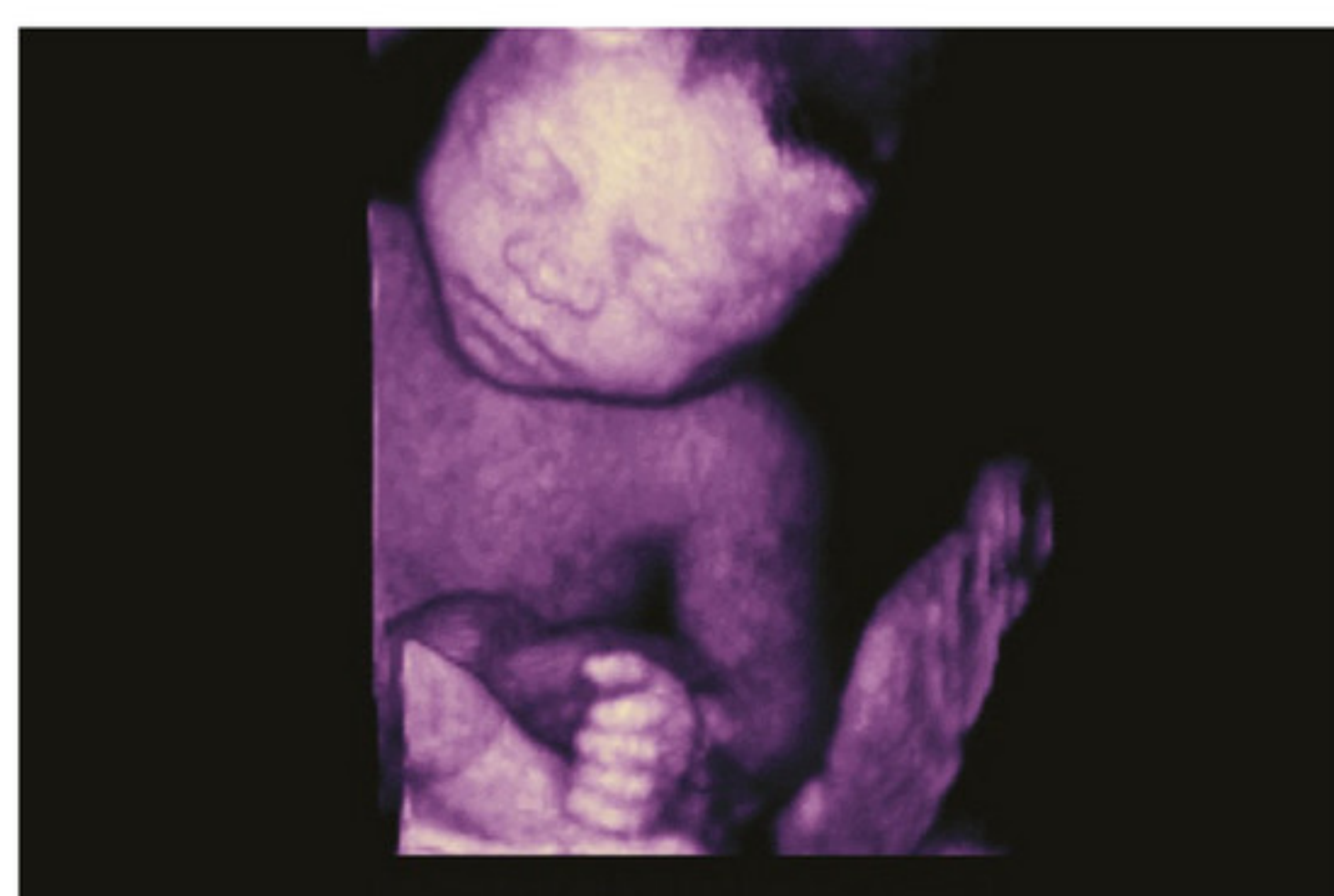
scanner head



1 having a scan



2 2D scan



3 3D scan

For many hereditary characteristics, scientists know exactly which chromosomes have the genes for those hereditary characteristics. The same also applies to certain alleles that cause genetic disorders. This makes it possible for a genetic researcher, using special techniques, to tell from a person's chromosomes whether they have the allele for one of these genetic disorders.

One of the chromosomes of a woman, for example, may have an allele that causes a hereditary form of breast cancer. That woman then has an 80 to 90% chance of getting breast cancer or ovarian cancer. Many women who have been found to have this allele choose a **mastectomy** (having their breasts surgically removed). This lets them prevent breast cancer. Other women choose to have their breasts examined thoroughly on a regular basis (see figure 70). Early-stage tumours can then be detected earlier. However, most forms of breast cancer are not hereditary.

GENETIC COUNSELLING

If an allele for a genetic disorder is detected in someone, this does not necessarily mean that they have the disease. They may also be a **carrier** of this allele. Carriers themselves are not ill, but they can pass this allele on to their children.

If a genetic disorder runs in someone's family, it is possible that he or she is a carrier of the allele that causes this disease. They are then in a **risk group**. If their partner is also a carrier, there is a chance that one or more children will have the genetic disorder. It is therefore recommended that people in certain risk groups should seek **genetic counselling**. A geneticist then examines how high the chance is that children would be born with a genetic disorder or an abnormality. With the help of genetic counselling, the man and woman can make a decision about a possible pregnancy. It is also recommended that genetic counselling should be sought if the woman has had multiple miscarriages.

WB EXERCISE 31, PAGE 37

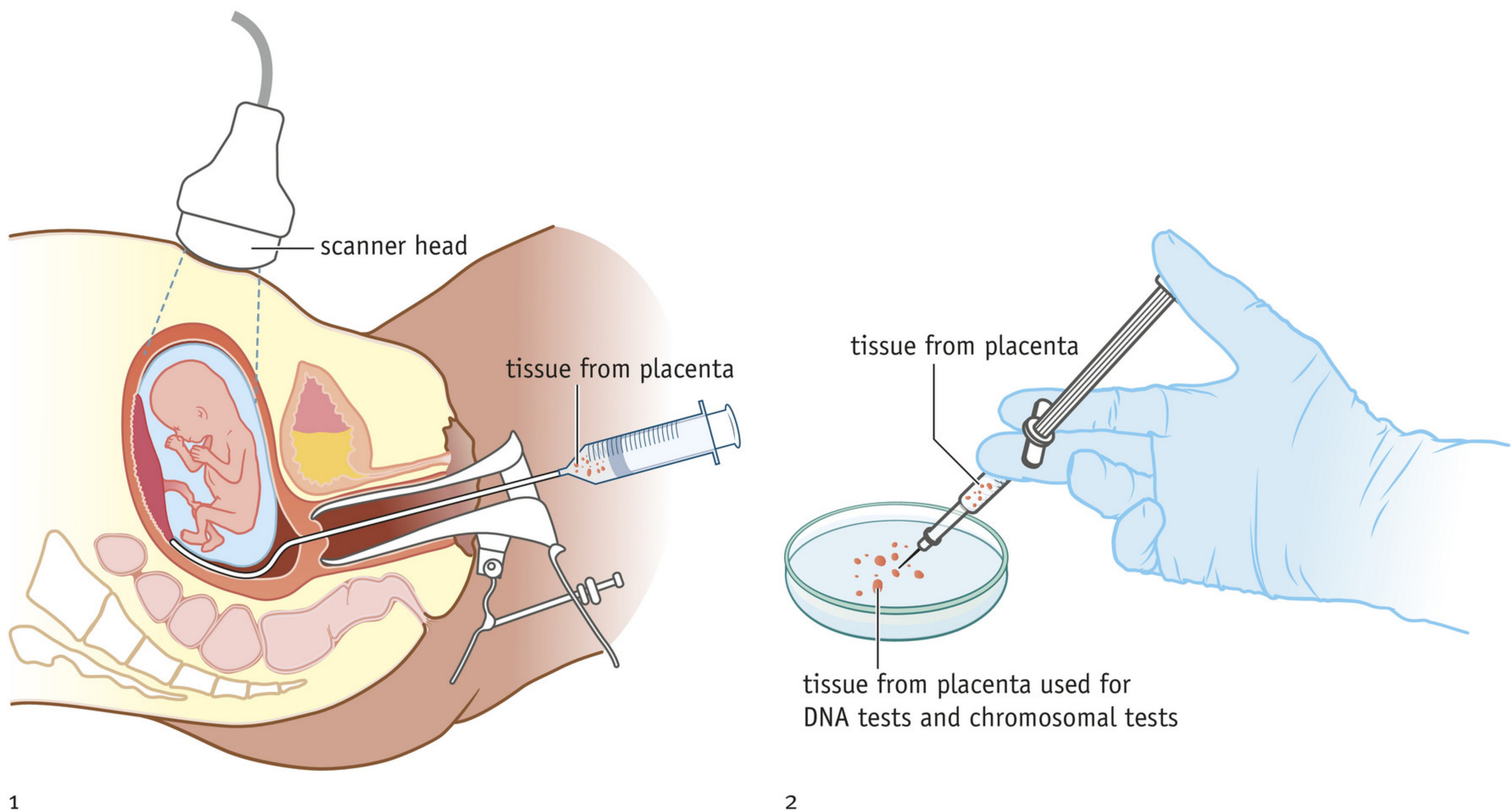
PRENATAL TESTING

Genetic testing is also carried out for embryos and fetuses. This is done to detect any diseases or abnormalities before the child is born. This testing may also be done through ultrasound scans, chorionic villus sampling or amniocentesis. These forms of testing are known as **prenatal testing**. Prenatal means 'before birth'.

Ultrasound is used to check the growth and position of the embryo or fetus using an **ultrasound scanner** (see figure 71.1). This device emits very high-frequency sound vibrations that are reflected differently by tissues and organs. The reflected vibrations are displayed on a screen as an image (see figure 71.2). Any abnormalities in the embryonic development can be detected this way. Ultrasound can be used from as early as the sixth week of pregnancy. Whether the fetus is a boy or a girl can only be determined after the reproductive organs have developed. It is also possible to use 3D ultrasound or to make a video of the fetus (see figure 71.3).

Chorionic villus sampling can be carried out from the eighth week of pregnancy. In this test, a little bit of tissue is removed from the placenta (see figure 72). This tissue contains cells from the embryo. Studying the chromosomes in these cells allows any abnormalities in the chromosomes to be detected. DNA testing is also done. One example of such an abnormality is **Down's syndrome** (see figure 73). You will learn more about this chromosomal abnormality in extension 3. A chorionic villus sample can also be used to determine whether the embryo will be a boy or a girl, based on the chromosomes. This is already possible before the reproductive organs have developed.

▼ **Fig. 72** Genetic testing using chorionic villus sampling.



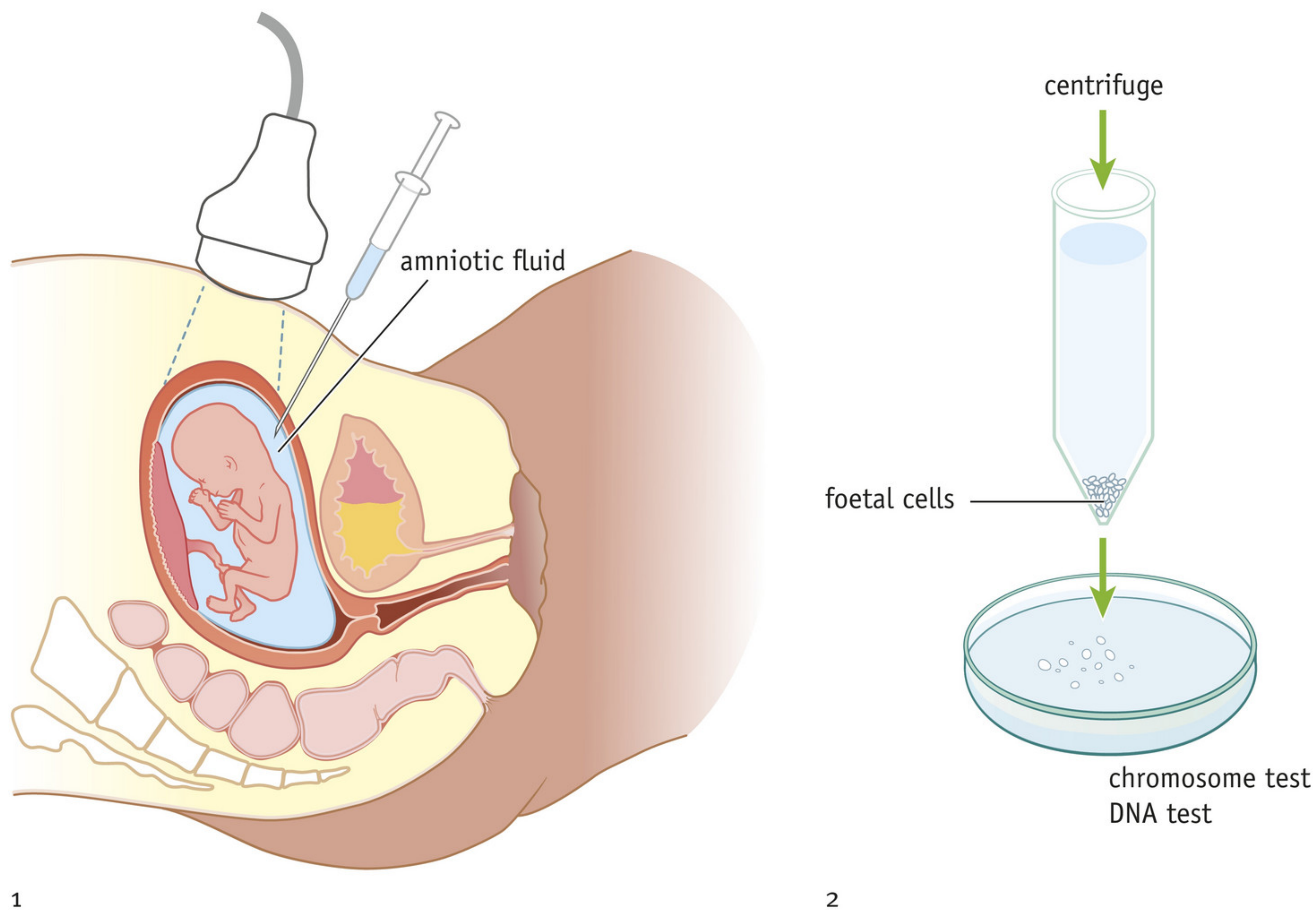
▼ **Fig. 73** Girl with Down's syndrome.



In **amniocentesis**, a little bit of amniotic fluid is extracted through the abdominal wall and the wall of the womb (see figure 74). The amniotic fluid contains cells from the foetus. These cells are used for chromosome testing and DNA tests. Amniocentesis can be carried out from the sixteenth week of pregnancy.

Chorionic villus sampling and amniocentesis are not entirely without risk. Such tests do slightly increase the chance of a miscarriage. These tests are therefore only carried out if there is a higher risk than normal that a child will be born with a severe illness or abnormality. This risk can also be higher if the woman has had several miscarriages before or if a genetic disorder runs in the family. If the woman is aged 36 or older, there is also a greater risk of having a child with an abnormality (see figure 75).

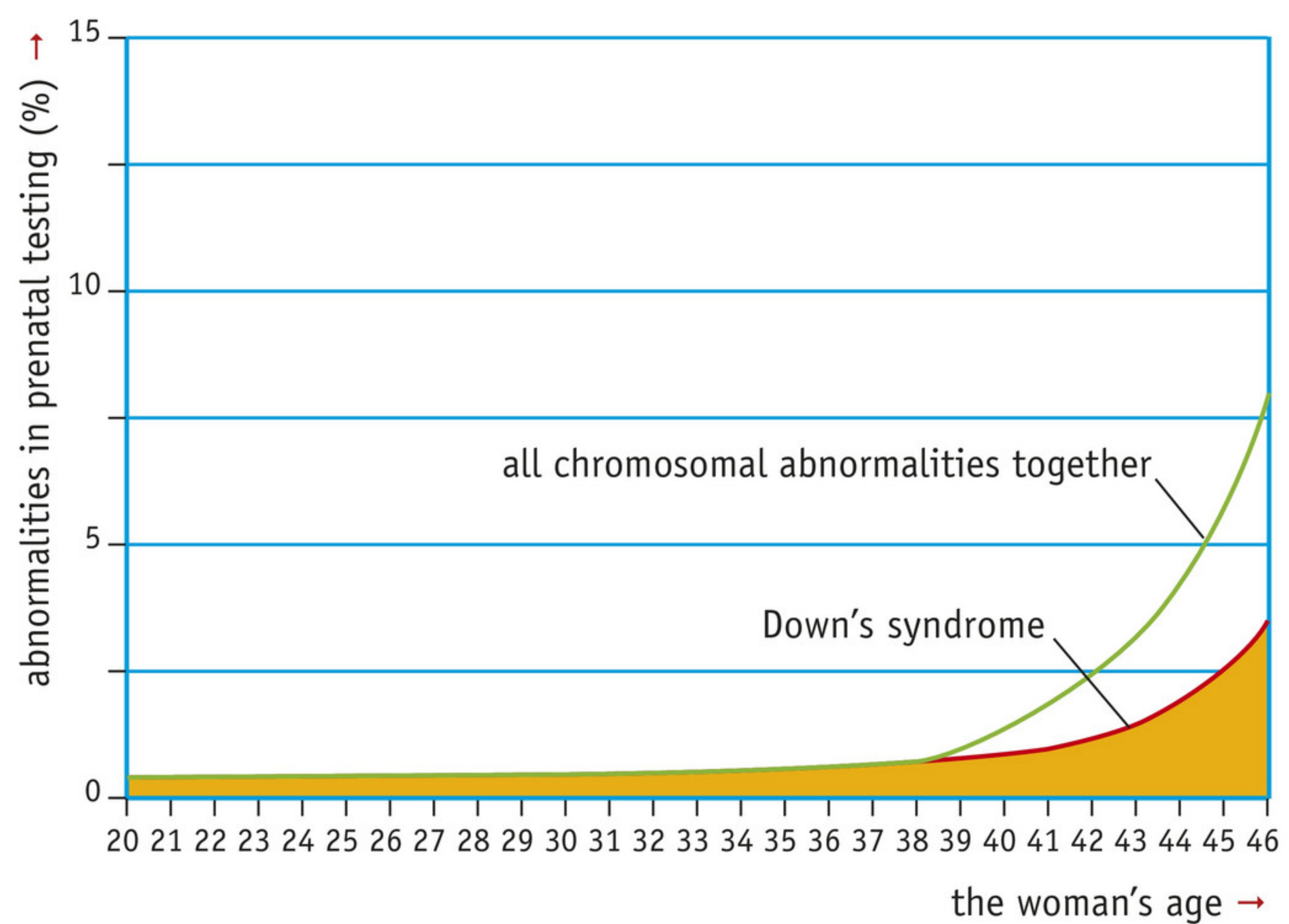
▼ **Fig. 74** Genetic testing using amniocentesis.



Sometimes it turns out that the unborn child has a severe illness or abnormality. The parents then may decide, in consultation with the doctor and other care staff, to have an **abortion**.

WB EXERCISE 32, PAGE 37

► **Fig. 75** The older the mother, the greater the chance of having a child with an abnormality.



Summary

OBJECTIVE 1

You can name the characteristics of chromosomes.

- Chromosomes are thin 'threads' found in the nucleus of each cell.
 - These threads contain the substance DNA.
 - DNA carries the information for inherited characteristics.
 - Each nucleus contains the complete information for all inherited characteristics of an organism.
- Each species of organism has a fixed number of chromosomes in every nucleus.
 - Every body cell in humans has a nucleus containing 46 chromosomes.
- The chromosomes in body cells occur in pairs.
 - The two chromosomes in a pair are matching.
 - In humans, the nucleus of each body cell contains 23 pairs of chromosomes.
- The chromosomes in sex cells do not occur in pairs; instead, there is just a single copy.
 - In humans the nucleus of each sex cell contains 23 chromosomes.

OBJECTIVE 2

You can describe what genotypes, phenotypes, genes and proteins are.

- Genotype: the information for the hereditary characteristics in an organism.
 - This information is found in the chromosomes in the nucleus of each body cell.
 - All genes in a nucleus taken together form the genotype.
 - An organism's genotype is determined at the moment of fertilisation.
- Phenotype: the external appearance (the visible characteristics) of an organism.
 - An organism's phenotype is determined by both the genotype and influences from the environment.
- Gene: a gene is a part of a chromosome that contains the information for a single hereditary characteristic.
 - DNA sequence of a gene: the building blocks of the DNA (A, C, G and T) occur in a specific order, one after the other.
 - This gives a code with the information for making a specific protein.

- Proteins make it possible to see the phenotype. Muscle proteins, for example, make it possible to see characteristics of muscles in the phenotype.
- Genes can be 'on' (expressed). Genes can also be 'off'.
 - This is related to the function of a cell.
 - For example: the genes for bile production are turned on in liver cells. These genes are turned off in skin cells.

OBJECTIVE 3

You can name the features of sexual reproduction.

- Allele: one of the genes of a pair (allele pair).
- In body cells, the two alleles of an allele pair contain information for the same hereditary characteristic.
 - This information can be identical or non-identical.
 - For example, the allele pair for hair type may contain information for straight hair and/or curly hair.
- One allele of each allele pair ends up in a sex cell during the formation of the sex cells.
 - This takes place randomly and makes sure that many different genotypes occur in sex cells.
- In sexual reproduction, two sex cells fuse.
 - Which genotype these sex cells will have depends on random chance.
 - Sexual reproduction leads to new genotypes in the offspring (variation in genotypes).

OBJECTIVE 4

You can describe what happens during fertilisation to result in identical twins and non-identical twins.

- Non-identical twins are created when two ova are fertilised.
 - Two sperm cells are involved in fertilisation.
 - Non-identical twins can be the same sex or can also be opposite sexes.
- Identical twins originate from a single fertilised ovum.
 - A single sperm cell is involved in the fertilisation.
 - During the early divisions of the fertilised ovum, the cells get separated from each other.
 - Identical twins are always the same sex.

OBJECTIVE 5

You can describe what a mutation is. You can also describe how cancer develops.

- Mutation: a sudden change in the genotype.
 - Mutant: an organism in which a mutation can be seen in the phenotype.
 - Mutations cause variation in genotypes.
- When there is a mutation in a body cell, this usually has no consequences.
 - The genotype of the other body cells remains unchanged.
- But if a mutation occurs in a sex cell, this may have a major effect.
 - The sex cell is involved in fertilisation. Every body cell of the offspring now carries the mutated gene.
- Mutations occur more often after exposure to mutagenic influences:
 - radiation (e.g. radioactivity, X-rays or the ultraviolet in sunlight);
 - certain chemical substances (e.g. in tobacco smoke or asbestos).
- How cancer develops: a cell starts dividing uncontrollably somewhere in the body.
 - Cause: probably due to mutations that have occurred in this cell.
 - It causes a tumour and disrupts the structure of the tissue.
 - A cure is still possible at this stage.
- Metastasis: cells from the initial tumour enter the blood and lymph.
 - These cells cause new tumours in other organs (metastases).
 - Cancer is very difficult to cure once metastasis has occurred.

OBJECTIVE 6

You can describe the principles of the theory of evolution.

- Evolution: the development of life on Earth in which species appear, change and/or disappear.
 - The theory of evolution assumes variation in genotypes, natural selection and the appearance of new species.
- In nature, we continuously find new genotypes (and phenotypes).
 - Variation in genotypes is caused by sexual reproduction and mutations.
- Natural selection.
 - Individuals that are better suited to their environment will have a greater chance of survival.
 - Organisms with a favourable genotype will have a relatively high number of offspring that survive and reproduce.
 - Species change when natural selection results in the survival of organisms with a new, altered feature while organisms with the original feature become extinct.
- Isolation can result in the creation of new species.
 - A group of organisms of a single species becomes isolated (separated) from the rest of their species.
 - Both groups continue to develop in different environments over a long period of time.
 - After millions of years, so many differences have arisen that organisms from the two groups are no longer able to reproduce. There are now two different species.

OBJECTIVE 7

You can describe how fossils have contributed to the theory of evolution.

- Fossils: mineralised remains of organisms, or the traces of organisms cast in stone.
 - Fossils are formed when remains of organisms are cut off from the surrounding air by a layer of sand or clay. This stops the remains from decaying.
 - Hard parts of organisms are fossilised more easily than soft parts.
 - A reconstruction of the whole organism is sometimes made from fossils of parts of organisms.
 - The fossil record tells us that over the course of evolution, species have appeared, changed and/or disappeared.

OBJECTIVE 8

You can describe how similarities between different organisms have contributed to the theory of evolution.

- Similarities in DNA, protein and phenotype.
 - The more similarities there are in the DNA, proteins and phenotypes of two species, the more likely it is that these species have a common ancestor.
 - Adaptation to the environment has caused the differences in genotypes and phenotypes.
- Similarities in phenotypes.
 - Similarity in structure. Organs with different functions can still be structurally similar. Examples: the wing of a bat, the front flipper of a whale, the front leg of a mole and the arm of a human.
 - Similarity in embryonic development. Embryonic development is similar in different species of animals.
 - Rudimentary organs: organs that have no function and are hardly developed, if at all. Examples of rudimentary organs: the pelvis of a whale, the remnants of legs in some giant snakes, the tail vertebrae and the caecum in humans. These organs may still be fully developed and used in related species.
- Similarity in processes (cell division, for example).

OBJECTIVE 9

You can read off a geological time scale.

- A geological time scale shows the time since the Earth was formed.
 - A geological time scale is divided into eras.
 - Each era is subdivided into periods.
- The numbers in a geological time scale indicate the time in millions of years ago.

OBJECTIVE 10

You can read off a branching tree of all organisms.

- The kinship between species is closer if they have a more recent common ancestor.
 - The longer ago that two species had a common ancestor, the less closely related they are.
- You can read off the following information from a branching tree of organisms:
 - what other groups a group of organisms developed from;
 - which groups are closely related to each other and which groups are not closely related.

OBJECTIVE 11

You can give examples of the applications of biotechnology.

- Biotechnology: the name given to a variety of techniques whereby living organisms are used in the production of goods for humans.
 - Biotechnology is used for producing foods, medicines, hormones and enzymes.
- Examples of biotechnology in which the hereditary characteristics of organisms are not changed:
 - yeast is used in the production of bread, beer and wine;
 - bacteria are used in the production of yoghurt and sauerkraut.
- Genetic modification: humans alter the inherited characteristics of other organisms.
- Recombinant DNA techniques: new genetic information is inserted into the DNA of an organism (for example DNA derived from another organism).
 - The altered organisms can then produce foods, medicines, hormones or enzymes that are either new or cheaper.
 - Example: bacteria can produce the hormone insulin if the human gene for producing insulin is inserted into bacterial DNA.
- Cloning: an artificial way of reproducing organisms, resulting in offspring that all have the same genotype as the cloned organism.
 - Cloning is a form of asexual reproduction.
 - It is possible to clone animals using nuclear transfer techniques, for example.
 - Nuclear transfer: the cell nucleus of a body cell is inserted into an egg cell; the nucleus of the egg cell has been removed beforehand. A clump of cells develops from the egg cell: this clump of cells can be inserted into the womb of a surrogate mother and can grow into a new organism.

- Genomics: the study of the entire DNA of an organism (or a large part of it) with all the genes on it.
 - In the livestock farming sector, bull calves with a suitable genotype are selected; they can be used as breeding bulls immediately once they reach sexual maturity.
- Using DNA tests to fight crime.
 - Each one of us has their own unique DNA.
 - If skin flakes, hair, sperm or blood traces are found at the scene of a crime, the DNA from the cells can be examined.
 - This DNA can be compared against DNA from different suspects.

EXTRA OBJECTIVE 12

You can describe what homozygous, heterozygous, dominant and recessive mean.

- Homozygous: the allele pair for a characteristic is made up of two identical alleles.
- Heterozygous: the allele pair for a characteristic is made up of two non-identical alleles.
- Dominant allele: an allele that is always expressed in the phenotype.
 - A dominant allele is indicated by a capital letter.
 - Organisms where a dominant allele is expressed in the phenotype may be homozygous or heterozygous for this characteristic.
- Recessive allele: an allele that is only expressed in the phenotype if there is no dominant allele present.
 - A recessive allele is indicated by a lowercase letter.
 - Organisms where a recessive allele is expressed in the phenotype are homozygous for this characteristic.

EXTRA OBJECTIVE 13

You can give examples where genetic counselling is recommended. You can also describe methods for prenatal testing.

- Genetic counselling: a geneticist examines how high the chance is that children would be born with a genetic disorder or an abnormality.
 - With the help of genetic counselling, the man and woman can make a decision about a possible pregnancy.

- Genetic counselling is recommended for people who are in a risk group. For example if:
 - a genetic disorder runs in the family;
 - the woman has had multiple miscarriages.
- Prenatal testing: to see before the birth if a child has a genetic disorder or abnormality.
 - Ultrasound: Sound waves are used to create an image of the embryo on the screen.
 - Chorionic villus sampling: a small amount of tissue is taken from the placenta. The chromosomes and the DNA of cells from the embryo are examined.
 - Amniocentesis: a small amount of amniotic fluid with foetal cells is taken from the womb. The chromosomes and the DNA of cells from the embryo are examined.
- The parents may consider abortion if the unborn child has a severe illness or abnormality.

SKILLS AND COMPETENCIES**BASICS**

- You have practised getting information from newspaper articles.
- You have practised drawing conclusions from scientific research.
- You have practised giving arguments for your opinion when making the case for a standpoint.

EXTRA

- You have practised making a diagram of chromosomes and alleles in a cell.

The diagnostic test does not include any questions about these competencies/skills.

You have met a computational biologist in this unit. You have also seen applications in science and daily practice that use the material from this unit.

Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the score sheet in your workbook.

OBJECTIVE 1

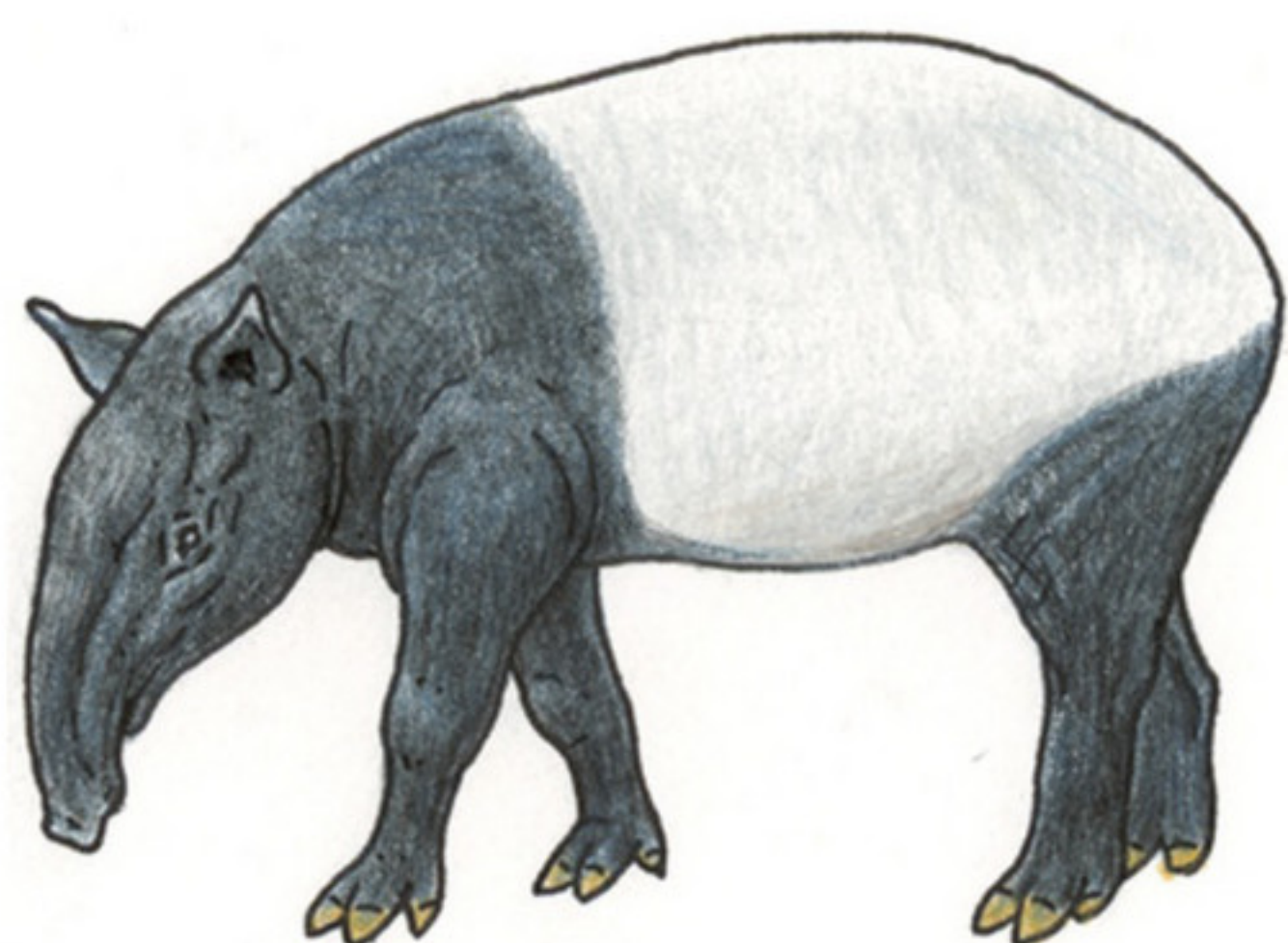
Answer the following questions.

- 1 What substance in the nucleus contains the information for hereditary characteristics?
- 2 How many chromosomes does a human liver cell contain?
- 3 How many chromosomes does a human ovum contain?

Figure 76 shows a Malaysian tapir. The sex cells are formed in the same way as in humans, but a body cell of a tapir has 52 chromosomes

- 4 How many chromosomes does a sperm cell of a Malayan tapir contain?

▼ Fig. 76



OBJECTIVE 2

Answer the following questions.

A certain gene in humans contains the information for producing an enzyme in the saliva.

- 1 Does a cell in your liver contain this gene?
- 2 Is this gene 'on' in the cells in your stomach?

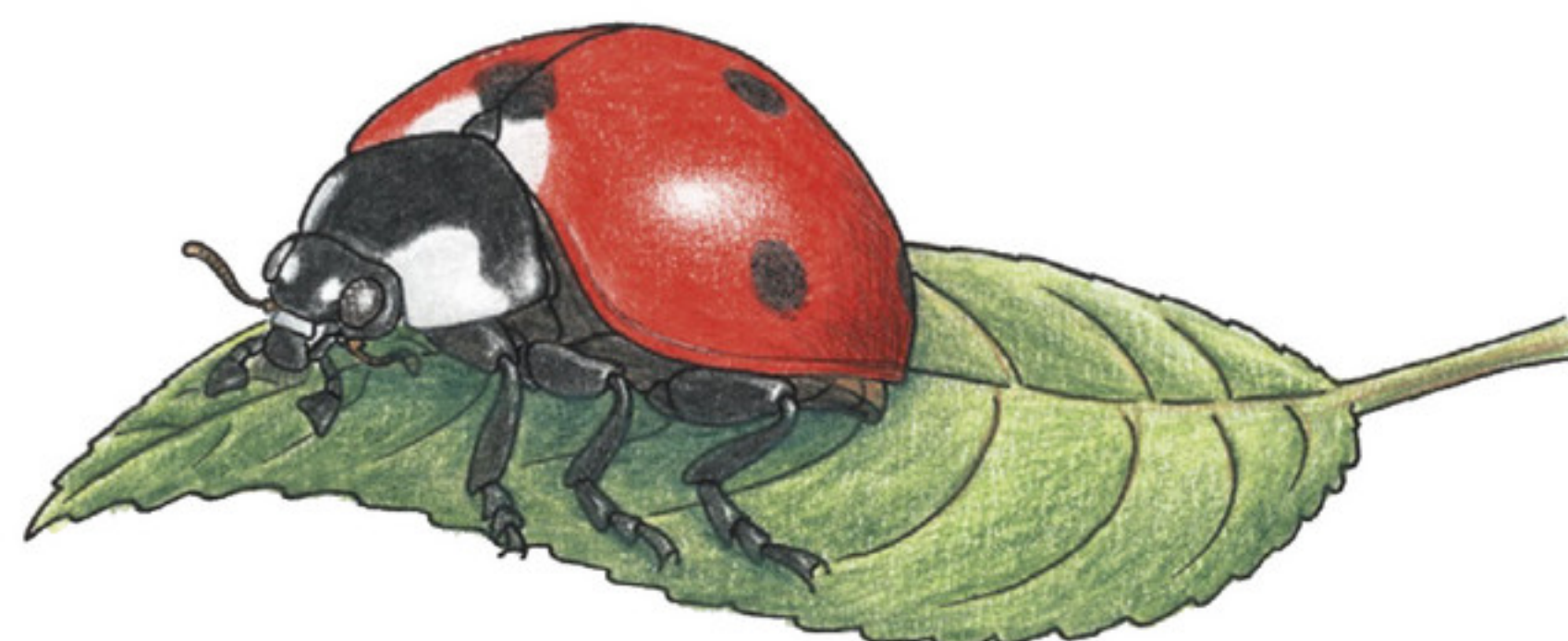
Questions 3 and 4 are about the animal in figure 77.

- 3 Do the larva and the adult animal have the same phenotype?
- 4 Do the larva and the adult animal have the same genotype?

▼ Fig. 77 The same individual at two different moments.



1 larva of a ladybird



2 the same larva has now reached the adult stage

- 5 The colour of the iris of humans is a hereditary characteristic (see figure 78). The colour of the iris of some humans is brown. This brown colour is caused by the protein melanin. Three steps that you can use to explain this are given below. Write down the numbers of these steps in the correct order.

- 1 The brown-eyed phenotype becomes visible.
- 2 The gene with information for the protein melanin is turned on in the cells of the eye.
- 3 The protein melanin is produced in the eye cells.

▼ Fig. 78



OBJECTIVE 3

Say whether each of the following statements is true or false.

- 1 The two alleles of an allele pair contain information for the same hereditary characteristic.
- 2 The information stored in the two alleles of an allele pair is always the same.
- 3 Sexual reproduction generates new genotypes in the offspring.
- 4 All the sperm cells of one man have the same genotype.
- 5 An ovum has the same genotype after fertilisation as before fertilisation.

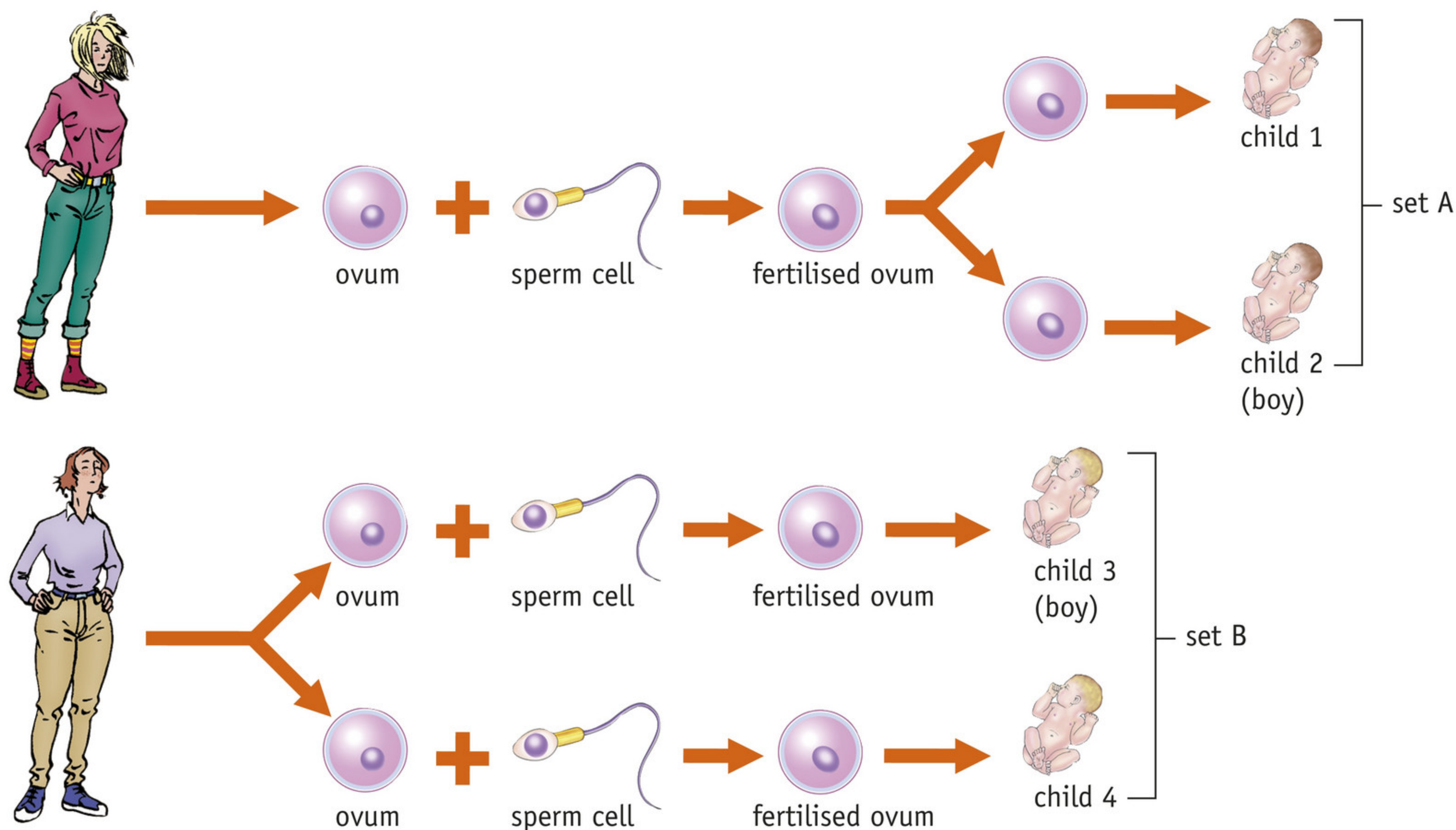
OBJECTIVE 4

Answer the following questions.

Figure 79 is a diagram showing how two sets of twins occur. Children 2 and 3 are boys.

- 1 Which twins are most alike, set A or set B?
- 2 Could child 1 be a girl?
- 3 And could child 4 be a girl?

▼ Fig. 79

**OBJECTIVE 5**

Answer the following questions.

- 1 Figure 80 shows you a ferret with the wild-type colouring and an albino ferret. The albino phenotype in ferrets was once caused by a mutation in a single ferret that had a lot of offspring. Did this mutation probably take place in a body cell or in a sex cell?
- 2 If mutations take place in a body cell, this does not generally have many consequences. Explain why mutations do sometimes have consequences when they occur in genes that control cell division.
- 3 Mutations have occurred in an intestinal cell of a man. As a consequence, a malignant tumour develops in one of his lungs after a while. Can you conclude from this that this man has probably been a smoker for much of his life? Explain your answer.

▼ Fig. 80 Ferret.



OBJECTIVE 6

Answer the following multiple choice questions.

- 1 Is the development of bacteria into unicellular plants an example of evolution?
A Yes.
B No.
- 2 If a species has a lot of different genotypes, does this species have a smaller or greater chance of survival?
A A smaller chance of survival.
B A greater chance of survival.
- 3 Bald uakaris have a red face (see figure 81). The brighter red the face is, the healthier the animal is. Sick animals have a paler face. The monkeys with the brightest red faces are best able to survive and will have the most offspring.
 Is the phenomenon that a bald uakari with a bright red face will have more offspring than one with a paler face an example of natural selection?
A Yes.
B No.

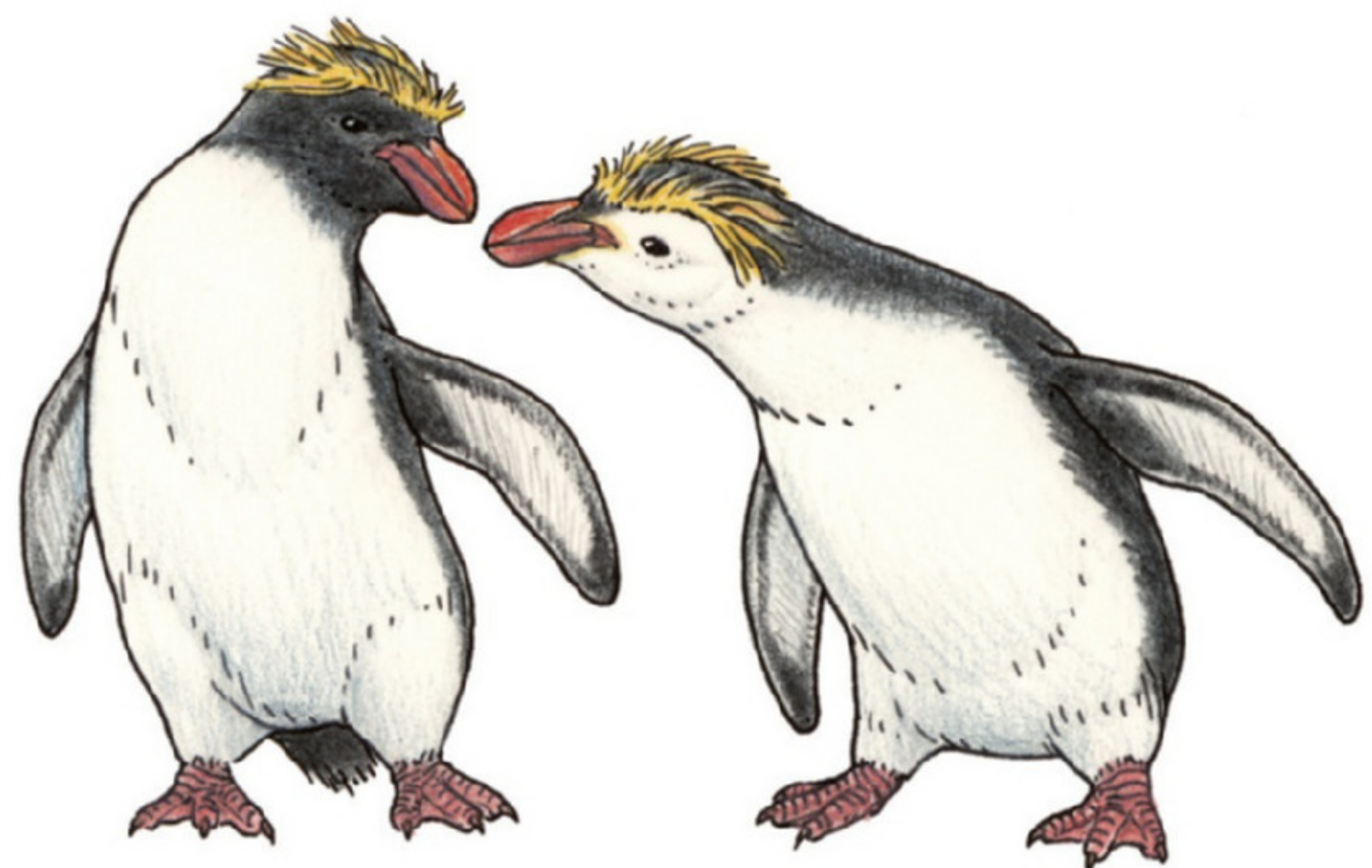
▼ **Fig. 81** Bald uakari (*Cacajao calvus*).



New forms of a species with a different phenotype have often appeared over the course of evolution. This sometimes caused the species to evolve (change). But sometimes the new form developed into a separate species. Questions 4 and 5 are about this development.

- 4 How can a different phenotype lead to evolution of the species?
A When the organisms of the original species become extinct and the organisms with the different phenotype survive.
B When the organisms with the different phenotype become extinct, and the organisms of the original species survive.
- 5 When can you say that the different form has developed into a new species?
A When the organisms with the different phenotype continue to reproduce with organisms of the original species.
B When the organisms with the different phenotype develop separately from the organisms of the original species.
- 6 Two types of crested penguins that are very much alike live in the Antarctic (see figure 82). Only the throat and cheek colours of the crested penguins are different. The two types of crested penguins have lived in isolation from each other for a long time. Biologists believe that type B emerged from type A. In which case can you say that types A and B are now different species?
A When the appearance of type B has become so different from type A that the two do not look alike anymore.
B When types A and B cannot reproduce together anymore.

▼ **Fig. 82** Crested penguins.



1 type A (macaroni penguin) 2 type B (royal penguin)

OBJECTIVE 7

Answer the following multiple choice questions.

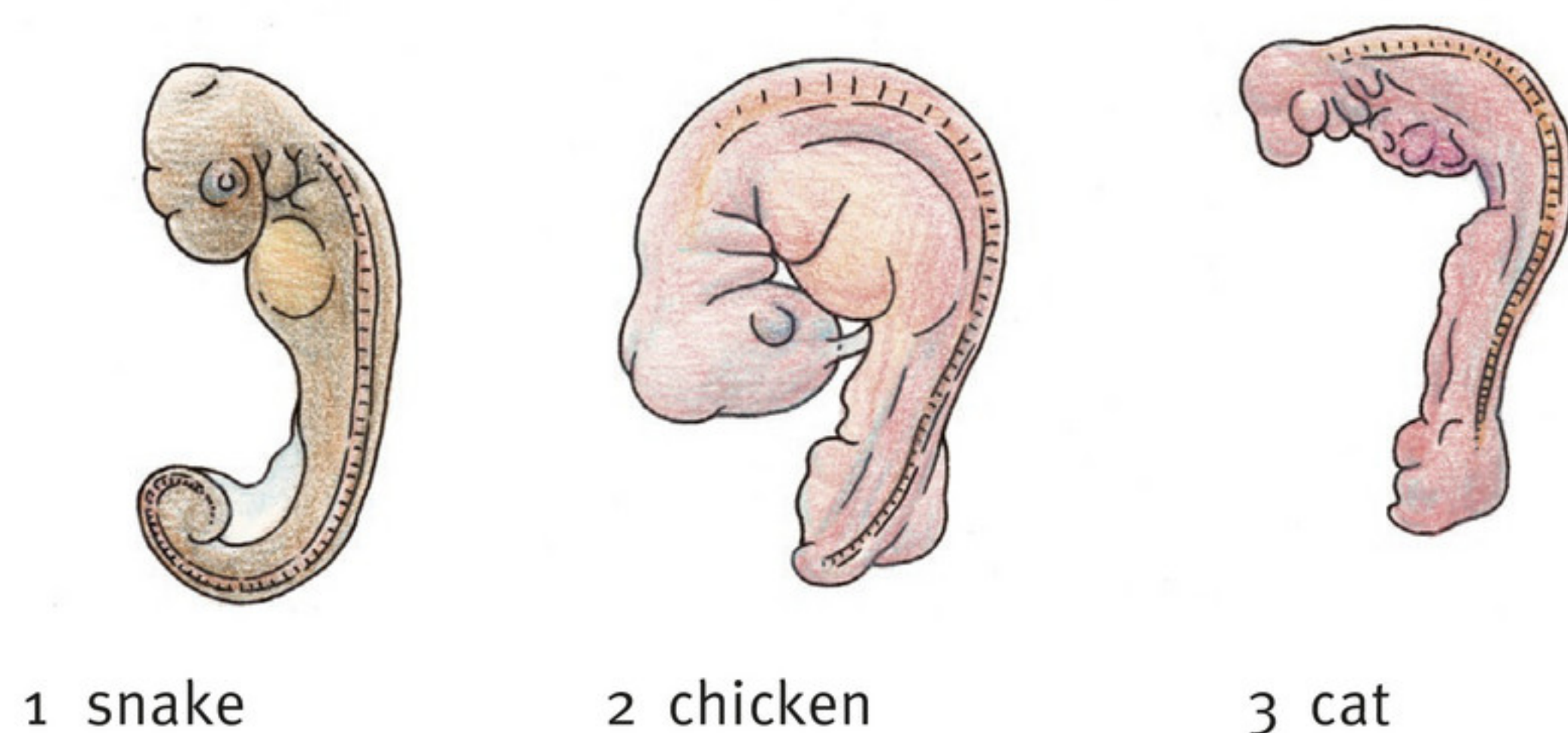
- 1 Which of the organisms listed below will fossilise best?
 - A A worm that continues to be exposed to air after it has died.
 - B A worm that is isolated from air by a layer of sand or clay after it has died.
 - C A beetle that continues to be exposed to air after it has died.
 - D A beetle that is isolated from air by a layer of sand or clay after it has died.
- 2 Alison says that fossils of unicellular organisms can occur in very old layers of rock.
 Lisa says that fossils of unicellular organisms can occur in the most recent layers of rock.
 Martha says that fossils of mammals can occur in the most recent layers of rock.
 Who is right?
 - A Only Alison and Lisa.
 - B Only Alison and Martha.
 - C Only Lisa and Martha.
 - D Alison, Lisa and Martha.

OBJECTIVE 8

Answer the following multiple choice questions.

- 1 What are rudimentary organs?
 - A Organs with a lot of similarities in structure, but with different functions.
 - B Organs that do not have a function any longer and do not develop, or hardly at all.
 - C Organs that only had a function and were fully developed in extinct species.
- 2 Which of the following organs are rudimentary?
 - A The tail vertebrae in humans.
 - B The wings of a bat.
 - C The wings of an insect.

▼ Fig. 83 Embryos.



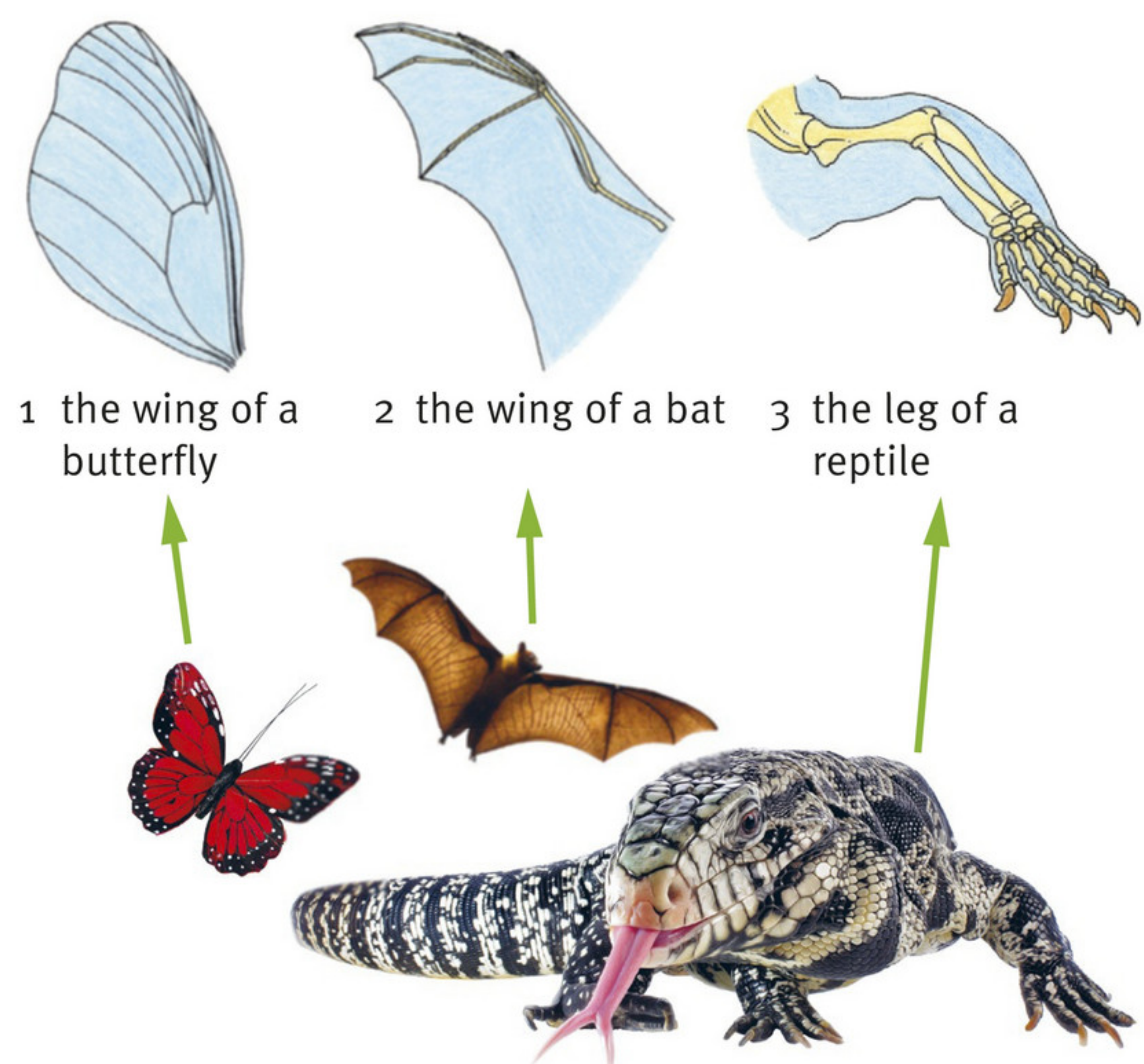
- 3 Figure 83 shows drawings of the embryos of a snake, a chicken and a cat. The embryos are all at a similar stage of development.

Is there a stage in the development where these embryos look more alike? If so, is this stage before or after the stage in the drawing?

- A No, there is no stage in their development where these embryos look more alike.
 - B Yes, these embryos looked more alike at an earlier stage of development.
 - C Yes, these embryos will look more alike at a later stage of development.
- 4 The DNA sequences of different species may look very much alike.
 Why is this similarity an argument for the theory of evolution?
 - A Because this similarity shows that species change, as organisms with different forms continue to exist and organisms with the original form become extinct.
 - B Because this shows how long ago the different species appeared.
 - C Because this similarity makes it likely that different species had a common ancestor.

Figure 84 shows drawings of the wing of a butterfly, the wing of a bat and the leg of a reptile. Questions 5 to 7 are about this figure.

▼ Fig. 84



- 5 Which of these organs have very similar structures?
A The wing of a bat and the leg of a reptile.
B The wing of a butterfly and the leg of a reptile.
C The wing of a butterfly and the wing of a bat.
- 6 Which of these organs have a very similar function?
A The wing of a bat and the leg of a reptile.
B The wing of a butterfly and the leg of a reptile.
C The wing of a butterfly and the wing of a bat.
- 7 Which of these organs probably originated from the same basic form?
A The wing of a bat and the leg of a reptile.
B The wing of a butterfly and the leg of a reptile.
C The wing of a butterfly and the wing of a bat.

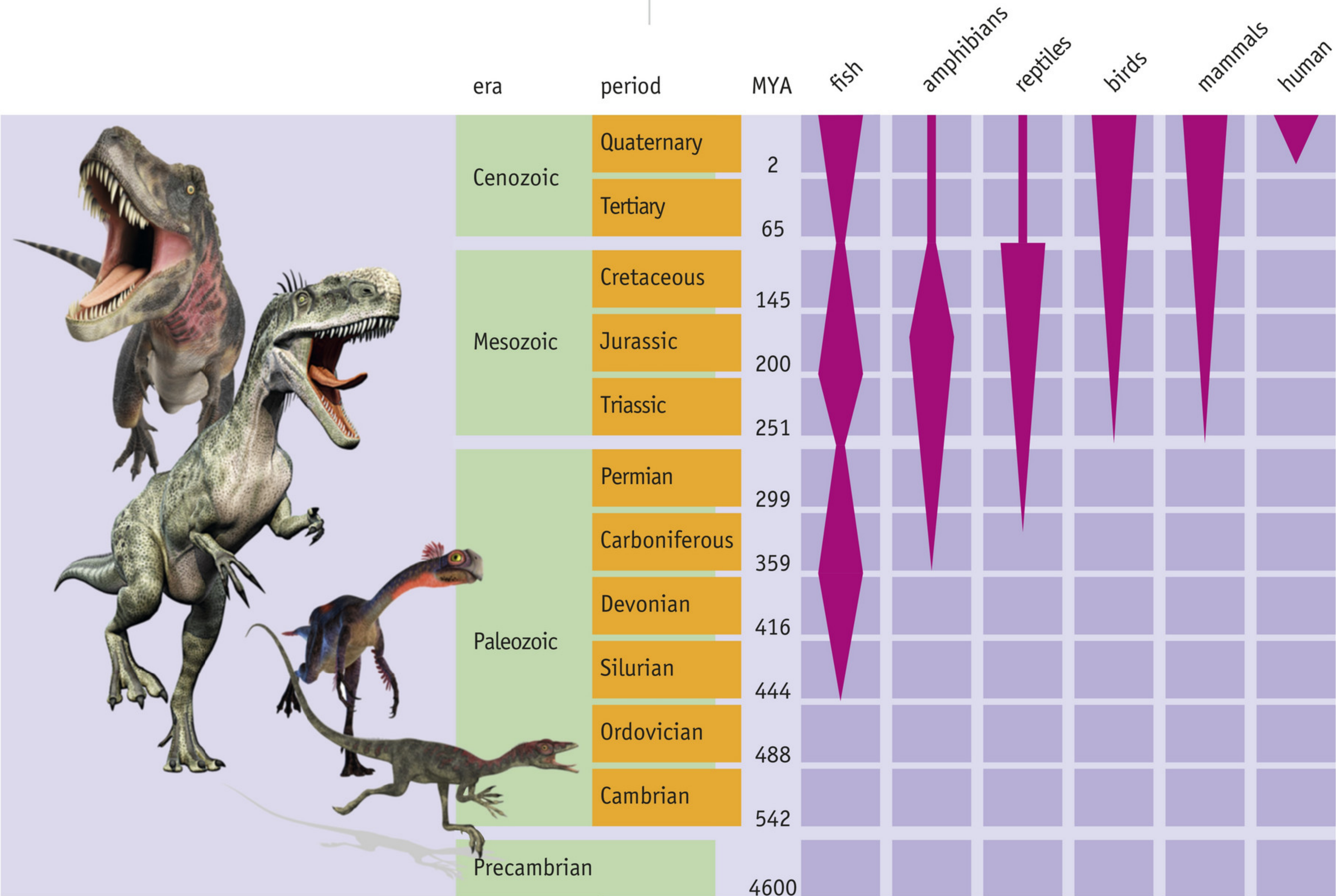
OBJECTIVE 9

Figure 85 shows a geological time scale. The broader the line, the more that group was flourishing at the time.

Use the figure to answer the questions below.

- 1 What periods is the Cenozoic era divided into?
2 How many millions of years ago did the Paleozoic era start?
3 How many millions of years did the Mesozoic era last?
4 How many millions of years ago did the first amphibians arise?
5 In which period did the first fish arise?
6 Which of the following lasted longer: the time before the first fish appeared, or the time since the appearance of the first fish until now?
7 At the end of which period did the animals in figure 85 become extinct?
8 Can bird fossils be found in rock layers from the Permian period?
9 Can fossils of mammals be found in rock layers from the Cretaceous period?

▼ Fig. 85 Geological timeline (MYA = millions of years ago).



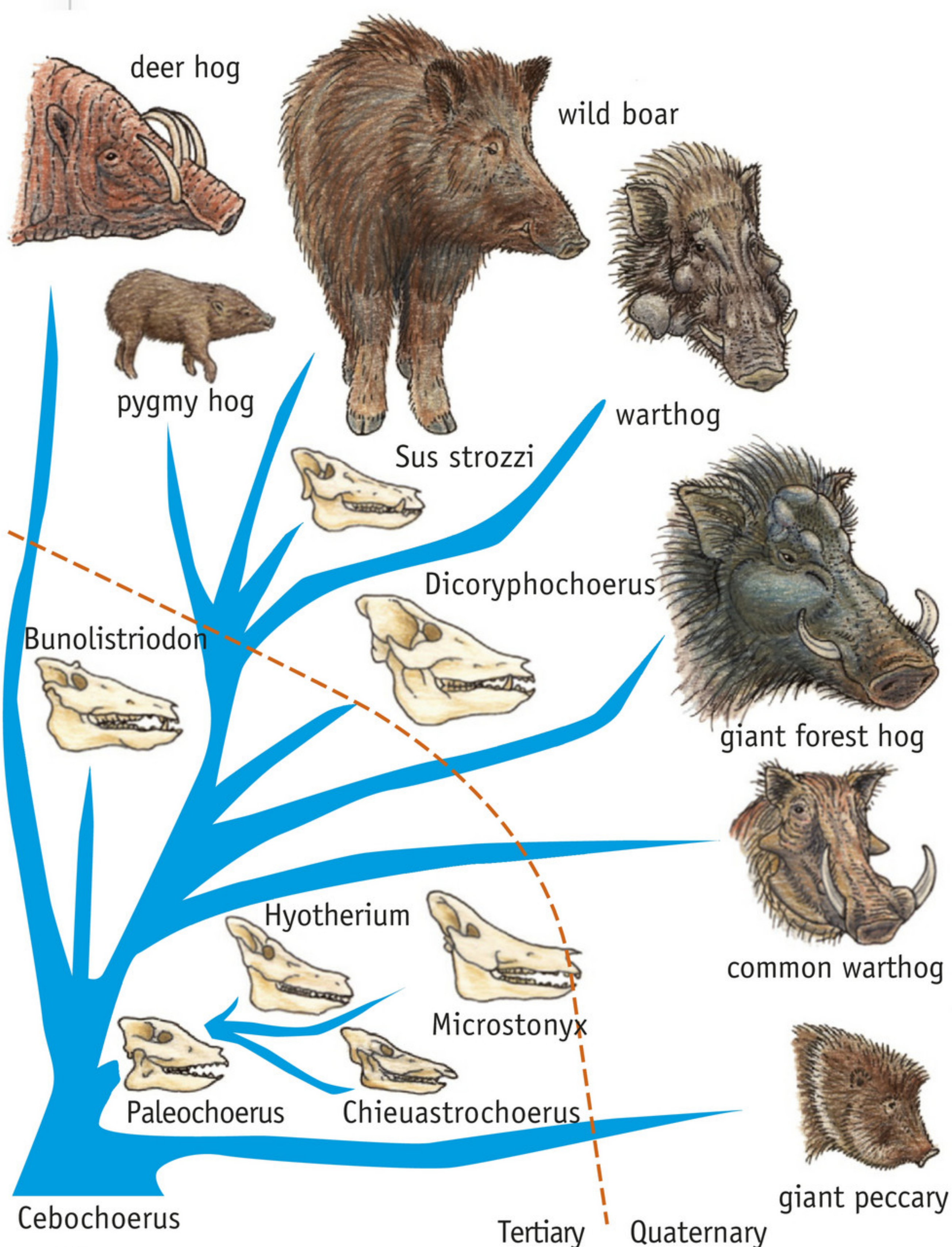
OBJECTIVE 10

Figure 86 shows a drawing of a branching tree of the development of the pig family.

Say whether each of the following statements is true or false.

- 1 Cebochoerus is the ancestor of the entire pig family.
- 2 Hyotherium appeared earlier than the giant peccary.
- 3 The wild boar and the deer hog are more closely related than the wild boar and the warthog.
- 4 Dicoryphochoerus became extinct earlier than Bunolistriodon.

▼ Fig. 86 The development of the pig family.



OBJECTIVE 11

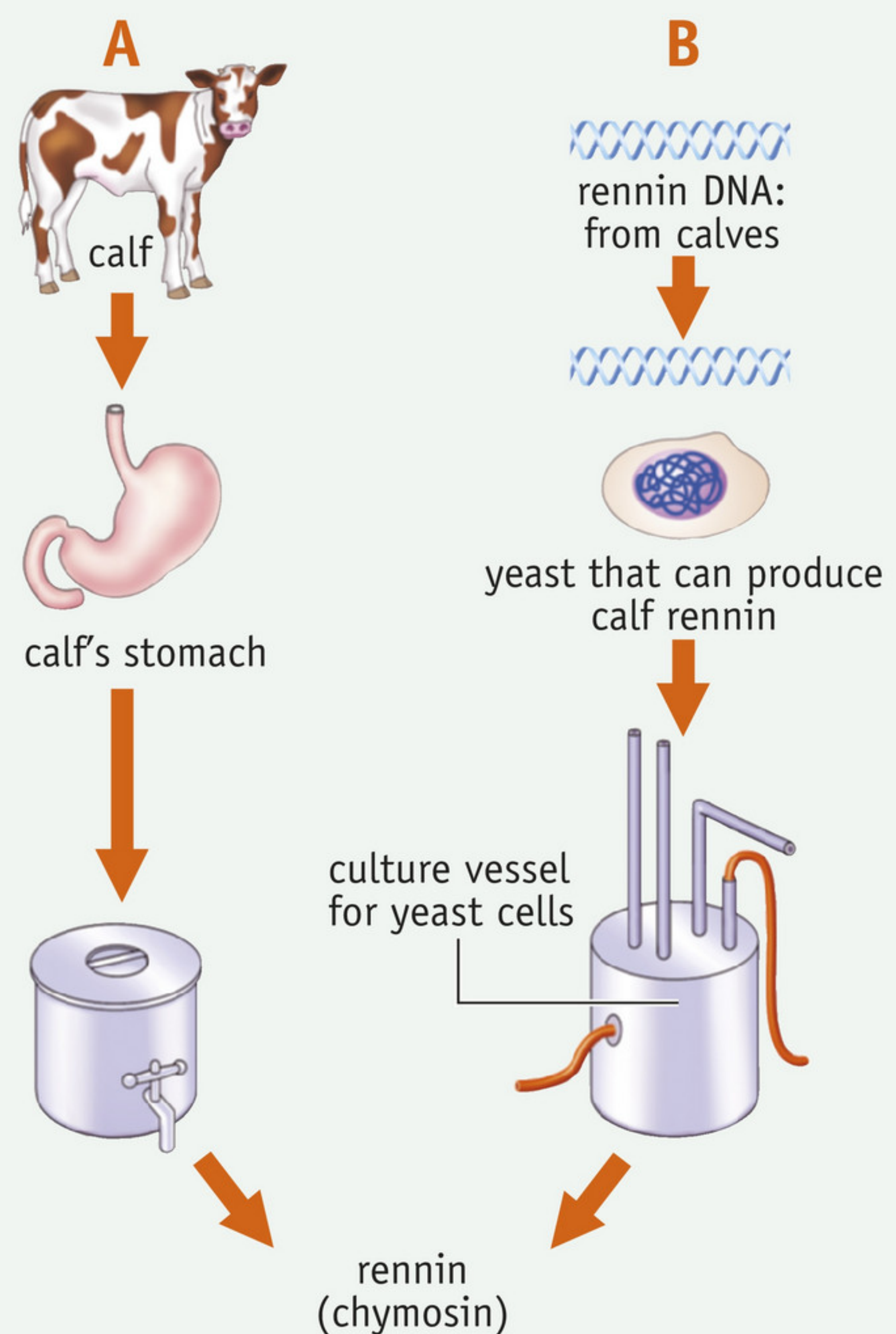
Answer the following questions.

- 1 Which form of biotechnology is figure 87 an example of?

▼ Fig. 87

Rennin

Rennin (also known as chymosin) is a substance used in preparing cheese. Adding rennin to milk will bind certain milk proteins together, which produces curds, a precursor to cheese. Rennin is traditionally extracted from the stomachs of calves (method A). Researchers have tried to produce rennin in different ways because of a shortage of rennin from calves' stomachs in certain countries. Research groups from various parts of the world have managed to take the DNA from calves for producing rennin and insert it into yeast cells (method B). Culturing these genetically modified yeast cells in culture vessels on a large scale means that rennin can now be produced in large quantities. There is another market for rennin produced by yeast cells: vegetarians prefer rennin that is made by yeast cells because calves do not have to be killed then.



- 2 Which form of biotechnology is figure 88 an example of?
- 3 Which form of biotechnology is figure 89 an example of?
- 4 Is biotechnology used in the production of bread?
- 5 Is Dolly the sheep in figure 88 a transgenic animal?
- 6 Which sheep has the same genotype as Dolly?

▼ Fig. 88

Dolly

Dolly the sheep was created from the genetic material of a single cell from the udder of a 6-year-old sheep (sheep 1). This genetic material was inserted into an egg cell (from sheep 2) from which the nucleus had been removed. The clump of cells that developed from this was then inserted into the womb of a surrogate mother ewe (sheep 3).

Because udder tissue was used, the Scottish scientists responsible for the experiment named the sheep after the busty country singer Dolly Parton.



▼ Fig. 89

EXTRA OBJECTIVE 12

Figure 90 shows a person with dwarfism and a person with normal growth. The allele for dwarfism (B) is dominant over the allele for normal growth (b) in humans.

Answer the following questions and complete the table on your score sheet.

- 1 Could person 1 be heterozygous for body growth? And person 2?
- 2 Can person 1 be homozygous for body growth? And person 2?
- 3 What are possible body growth genotypes for person 1? And for person 2?

▼ Fig. 90



1 dwarfism

2 normal growth

DNA test saves the lives of sick twins

The 15-year-old twins Alexis and Noah Beery turned out to be sick after they were born. They were affected by cramps, vomiting and symptoms of cerebral palsy. After a lot of tests, the complete DNA of the twins was finally mapped out and compared to the complete DNA of healthy people. This revealed a mutation in the SPR gene, which

contains the code for producing a protein that nerve cells need in order to control the muscles. The missing protein could be administered as a medicine. The twins are doing well now and are able to join in sporting activities again. The test saved their lives.



EXTRA OBJECTIVE 13

Answer the following multiple choice questions.

- 1** Four couples who would like to have children are described below. None of these couples already has a child.

- 1 Nathan and Arya. Nathan had a car accident a year ago and is in a wheelchair.
- 2 Joe and Raylene. Raylene's mother and grandmother died of breast cancer.
- 3 John and Maureen. Maureen has had two miscarriages.
- 4 Raymond and Naomi. Raymond had an eye infection a few years ago, which led to him going blind.

Which of these couples should seek genetic counselling?

- A** Couples 1 and 3.
 - B** Couples 1 and 4.
 - C** Couples 2 and 3.
 - D** Couples 2 and 4.
- 2** One of the methods for genetic testing of unborn children is chorionic villus sampling.
What is tested in chorionic villus sampling?
- A** The composition of the urine of a pregnant woman.
 - B** The composition of the DNA and the chromosomes from the amniotic fluid of a pregnant woman.
 - C** The DNA and the chromosomes of placental tissue from the mother.
 - D** The DNA and the chromosomes of placental tissue from the embryo.
- 3** Another method of genetic testing of unborn children is amniocentesis.
What are doctors trying to detect in amniocentesis?
- A** Any abnormalities in the DNA and the chromosomes from cells of the placenta.
 - B** Any abnormalities in the DNA and the chromosomes from cells in the amniotic fluid.
 - C** Any growth disorders of the embryo.
 - D** Any harmful substances in the amniotic fluid.

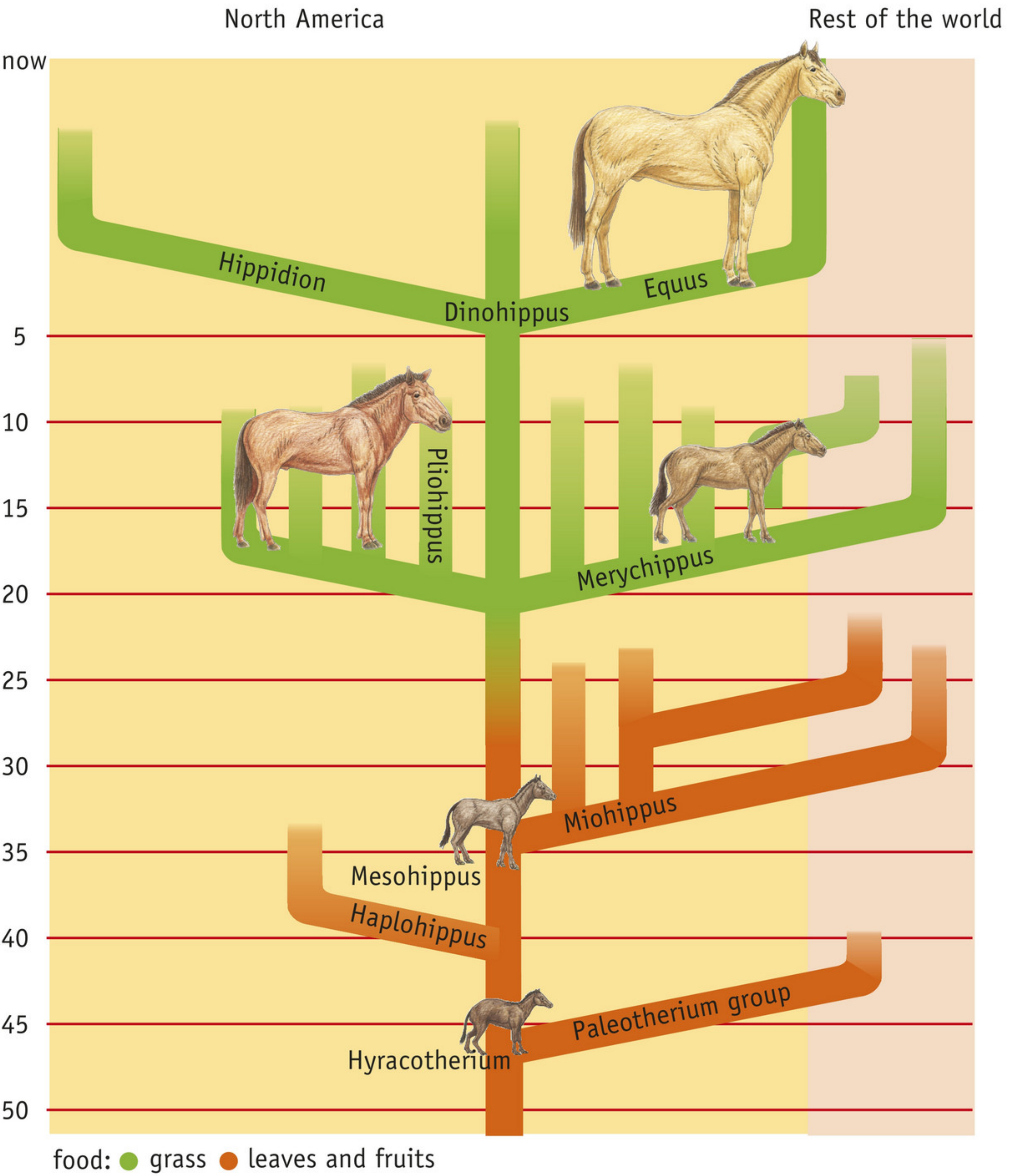
You can do the extension if you have time left over. You can choose between different topics. This unit’s extension consists of three topics. You should do the exercises in your workbook.

1 The evolution of the horse family

Over the course of evolution, modern horses evolved from a mammal as big as a dog. During millions of years, the horse family underwent changes in body size, the length of the legs, the number of toes that they walk on, their diet and their teeth. In this extension you will learn more about the way that these changes took place.

Figure 91 shows a family tree of the evolution of the horse family. This evolution largely took place in North America. Hyracotherium, the ancestor

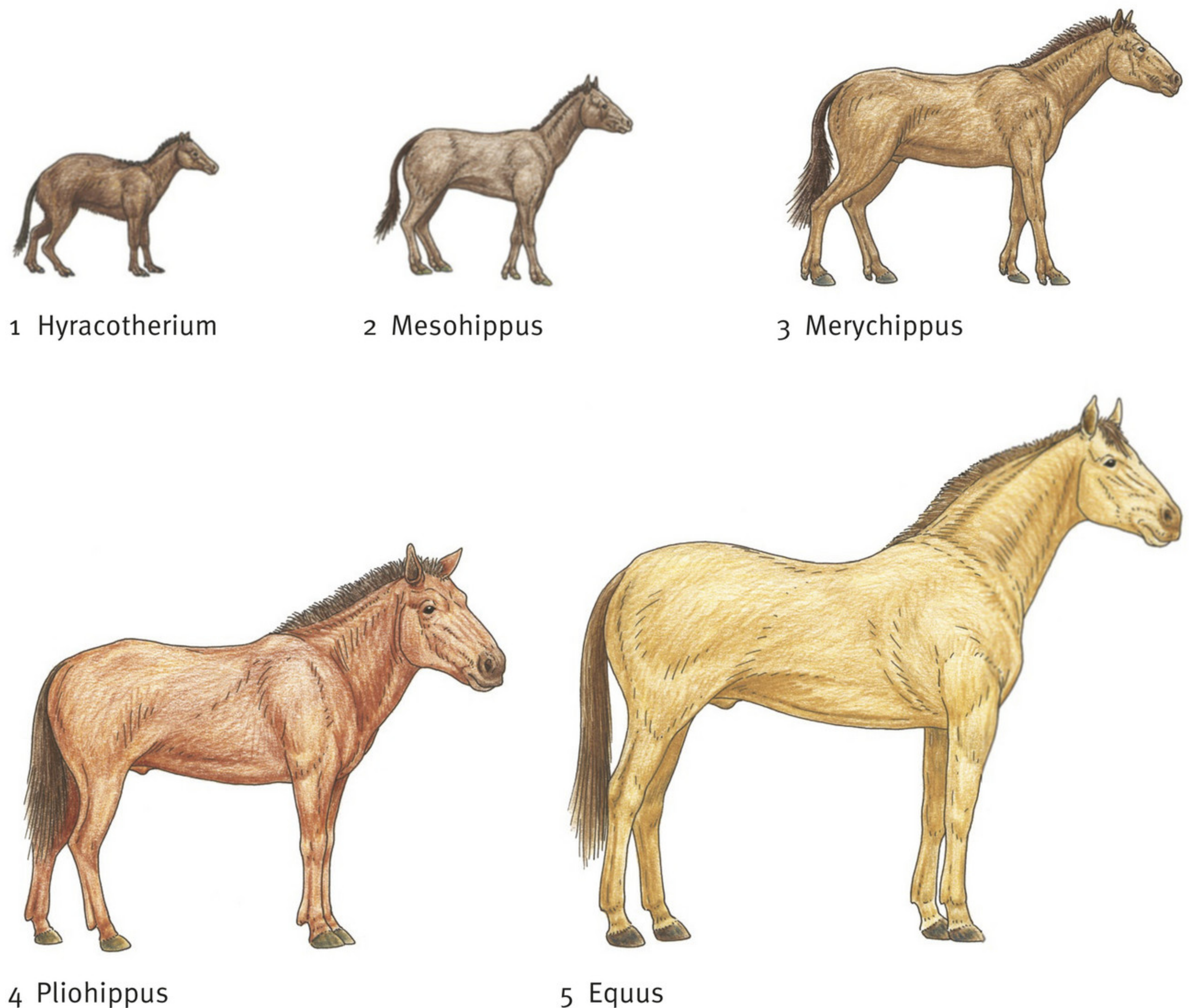
► **Fig. 91** Evolution of the horse family.



of the horse family, lived about 50 million years ago. It was a small animal, about the size of a dog, with thin legs (see figure 92.1). The animal hid in dense forests, where it mainly ate leaves and fruit.

Mesohippus also lived in forests, about 35 million years ago (see figure 92.2). When climate change caused forested areas to decrease in size, the horse family increasingly moved onto the open plains. Grass was the only available food source there. However, the tough grass of the plains was harder to digest than the leaves and fruits of the forests. The animals had to chew their food for much longer. As a result of natural selection, the horse family developed more and more powerful chewing muscles, bigger jaws and larger molars with stronger enamel ridges. The animals could not hide very well from predators on the open plains. Being able to flee quickly was therefore important. As a result of natural selection, the horse family developed longer legs. To minimise resistance from the ground, they started walking on fewer and fewer toes.

► **Fig. 92** The horse family.



Merychippus was already living on the open plains about 15 million years ago (see figure 92.3). Pliohippus also lived on the open plains, about 10 million years ago (see figure 93.4). The modern horse species is called Equus (see figure 92.5). In the wild, horses live on open, steppe-like plains. The animal's long legs let it run fast. The ground that the animal lives on is hard. Their food consists entirely of grass.

2 Stem cells

Your body consists of billions of cells that have specialised to become stomach wall cells or muscle cells for instance. When a specialised cell such as this divides, the daughter cells are of the same type as the parent cell. Muscle cell division therefore only produces muscle cells. There are also some cells that have not yet specialised, or only partly. Such a cell is called a **stem cell**. Stem cell division can result in different types of cells.

ADULT STEM CELLS

A lot of human organs contain **adult stem cells**. A range of different cell types can develop from these stem cells, but not all types. Only cell types that are in the organ that the stem cell comes from can develop from an adult stem cell. Various types of liver cells can develop from a liver stem cell, for instance, but not skin cells.

Adult stem cells can be inserted into diseased or damaged tissue and grow into healthy tissue there. Adult stem cells have been used for years in fighting leukemia, for example (see figure 93).

▼ Fig. 93

Olympic gold after a stem cell transplant

BEIJING – Top swimmer Maarten van der Weijden won Olympic gold in Beijing in the 10-kilometre race after a thrilling finale in open water. The special thing about this is that Van der Weijden is a former leukaemia patient. He conquered the disease after four chemotherapy cycles and a stem cell transplant. Your large bones contain red bone marrow at the centre. This red bone marrow contains adult stem cells that can grow into various types of blood cells. In leukaemia patients, stem cells in the red bone marrow are out of control and produce large numbers of abnormal white blood cells. Chemotherapy and radiotherapy make it possible to kill these malignant stem cells. However, the bone marrow then no longer contains any adult stem cells from which blood cells can develop. In a stem cell transplant, a leukaemia patient is given new adult bone marrow stem cells from a donor. These stem

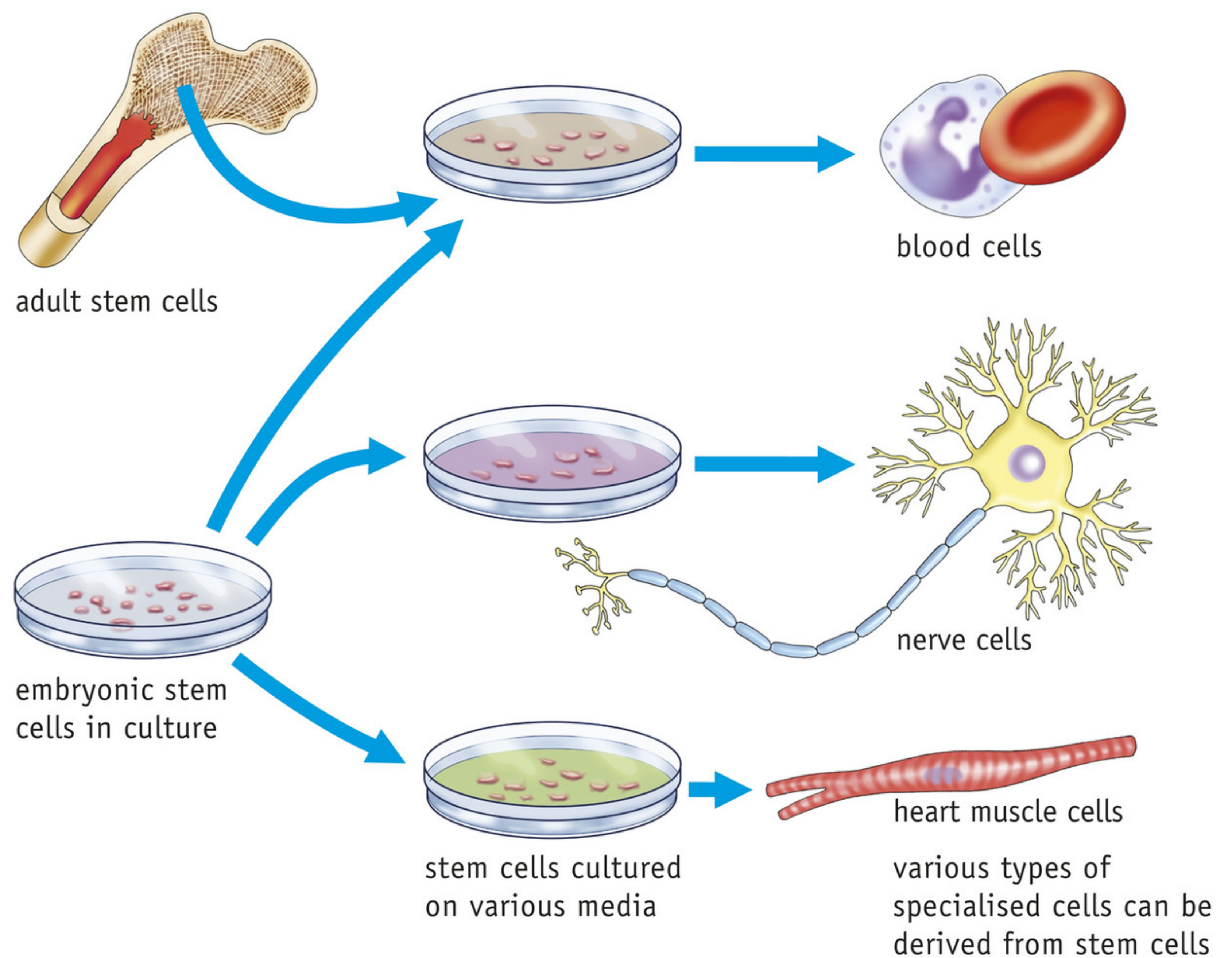
cells can then produce healthy blood cells again. Even enough for an Olympic champion.



EMBRYONIC STEM CELLS

Embryonic stem cells can still develop into any type of cell after division (see figure 94). A fertilised ovum is an example of this. The first cells that arise after the fertilised ovum has divided are able to grow into any type of cell. That is why these cells are seen as embryonic stem cells. Using embryonic stem cells may provide one way of fighting some diseases. For example, for people with chronic heart disease, embryonic stem cells could produce healthy heart muscle cells to replace heart muscle cells that have died off.

► **Fig. 94** Development of specialised cells from stem cells.



There are restrictions on how embryonic stem cells can be used in the Netherlands. Creating embryos that are only to be used for research purposes is forbidden. Embryonic stem cells are obtained from material that remains after in vitro fertilisation (IVF) has been performed. With permission from the parents these stem cells can be used, but only for research. Embryonic stem cells are therefore still not used for treating patients.

The young embryo is destroyed when experiments are done with embryos. Some people think that life begins when an ovum is fertilised. Or they say that it is not known precisely when life starts. They therefore believe that no experiments should be done with human embryos. Other people think that embryos in the early stages of development do not yet have human characteristics, such as sensation and consciousness. They say that you should be able use these embryos if they can help fight severe diseases.

Efforts are being made to find other ways to obtain cells that have the same capabilities as embryonic stem cells. For example, scientists have succeeded in adding certain genes to skin cells that make them behave like embryonic stem cells (see figure 95).

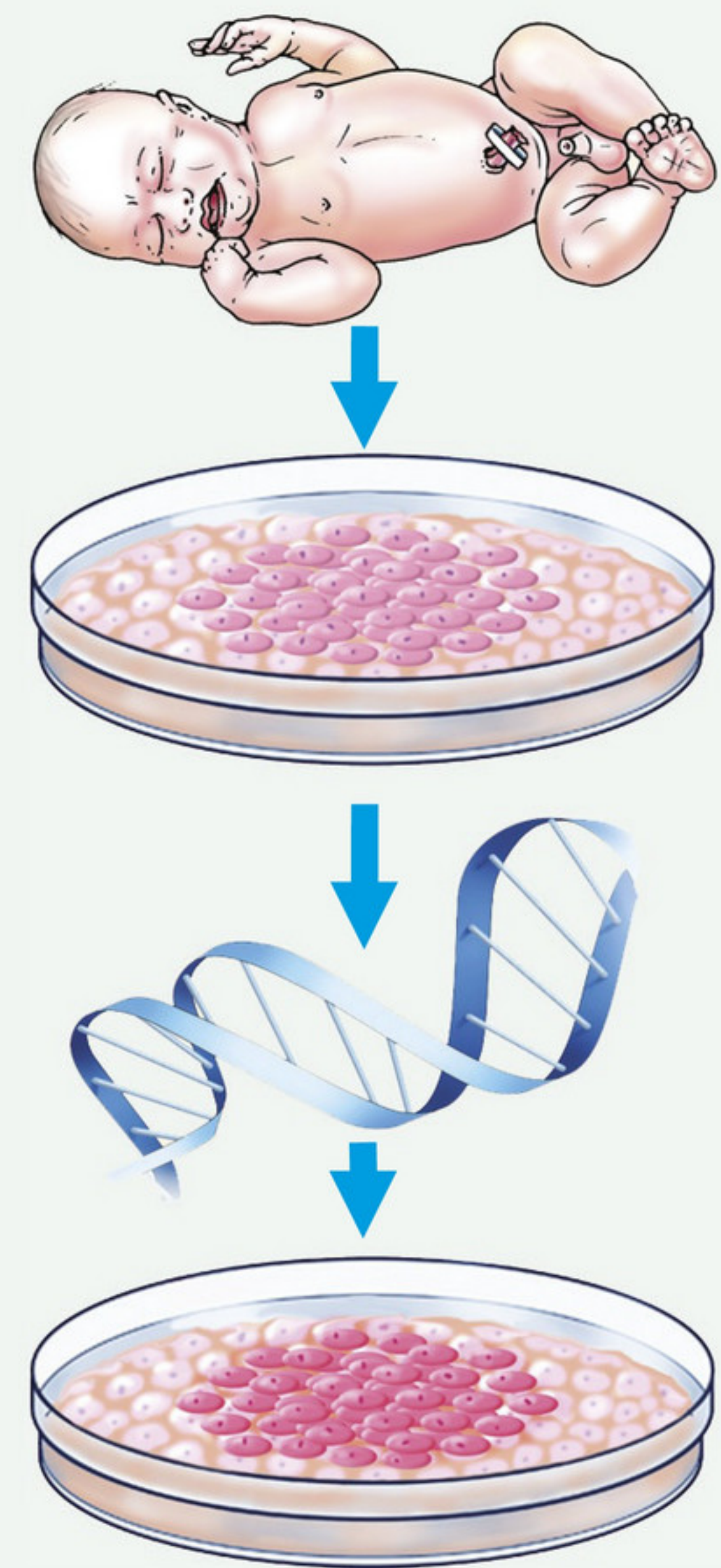
WB EXERCISE 1, PAGE 42

▼ Fig. 95

Successful isolation of stem cells from skin cells

Together with his research team, the American biologist James Thomson developed a new method for culturing embryonic stem cells. They reprogrammed human skin cells from a new-born baby by adding four genes to the skin cells. As a result, the skin cells behaved exactly the same as embryonic stem cells. What makes this special is that the genes were added temporarily, using a small round chromosome that disappears by itself later on. This means that the stem cells are not contaminated with 'foreign' genes; the risk of cancer will therefore remain low.

The method seems very promising, because embryonic stem cells can grow into any type of body cell. Furthermore, the body's own cells can be used, which eliminates the chance of rejection. This technique is still under development and still needs to be tested in further cultures.

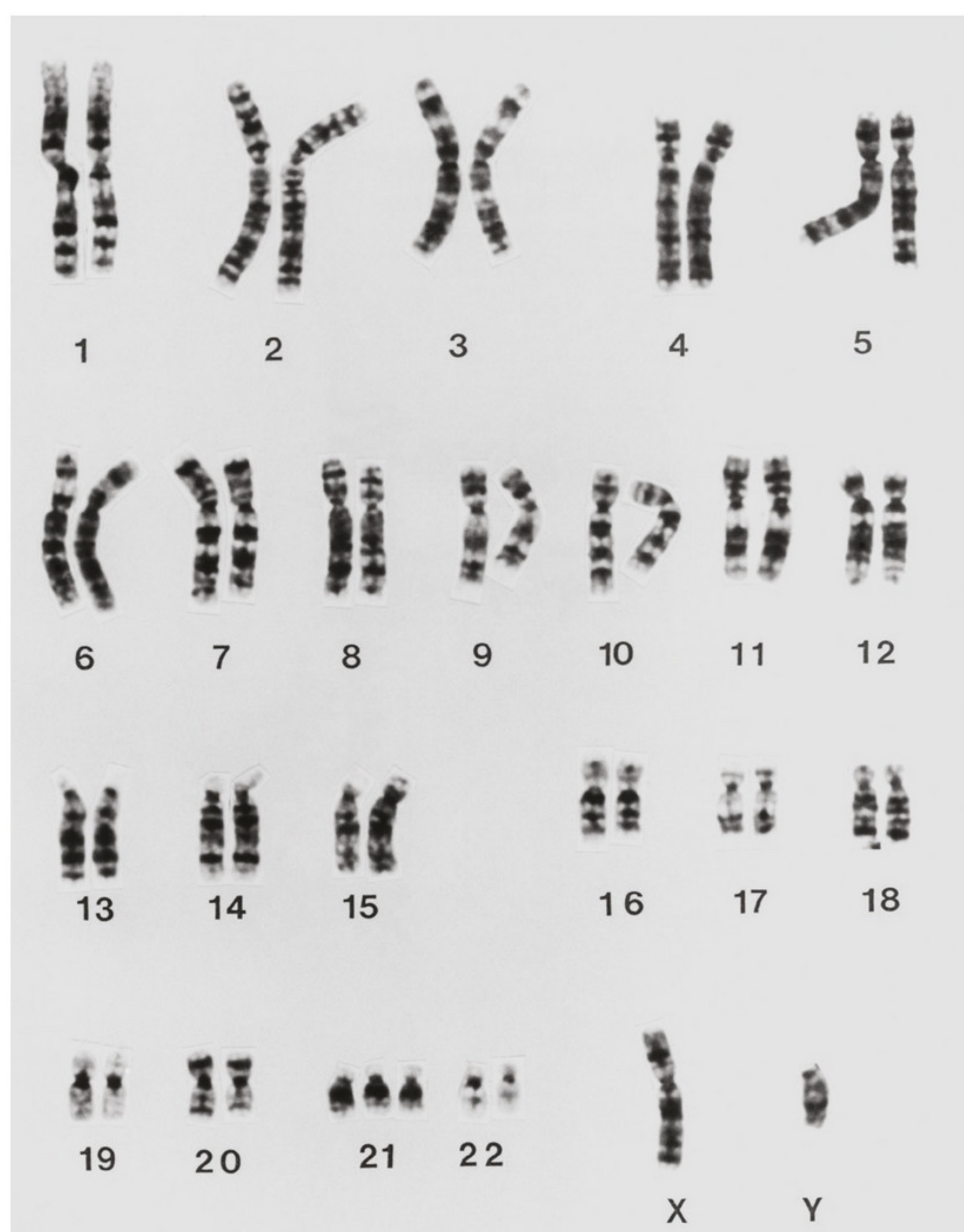


3 Down's syndrome

In extra 10 you learned that any abnormalities in the chromosomes of unborn children can be detected before birth using chorionic villus sampling or amniocentesis. In this extension you will learn more about one of these chromosomal abnormalities, **Down's syndrome**. You have to answer questions and interview somebody.

Chorionic villus sampling and amniocentesis involve chromosomal tests. A chromosome portrait known as a **karyogram** is then made from the chromosomes. This is an image where all chromosomes of a cell are arranged in pairs. You have already seen a karyogram in figure 5. A karyogram may sometimes show that there are additional chromosomes or that chromosomes are missing. Figure 96 shows the karyogram of a person with Down's syndrome. This person's cell nuclei have a third copy of chromosome number 21. The condition is therefore also known as **trisomy 21**. The abnormal number of chromosomes leads to the typical facial appearance and often slow mental development. Nevertheless, people with Down's syndrome sometimes have paid jobs (see figure 97).

► **Fig. 96** Karyogram of a person with Down's syndrome.



Down's syndrome develops when there is a duplicate of chromosome 21 in one of the sex cells that are involved in fertilisation. It is probably caused by abnormal progress of the cell division that generates sex cells.

A sex cell that has a duplicate of chromosome 21 has 24 chromosomes. During fertilisation, such a sex cell can fuse with a normal sex cell containing 23 chromosomes. This then creates a fertilised ovum with 47 chromosomes. This fertilised ovum then grows into a person with 47 chromosomes in every body cell.

WB EXERCISES 1 TO 3, PAGE 43

► **Fig. 97** A man with Down's syndrome at work.



▼ **Fig. 98**

I'm proud of my daughter

A mother of a child with Down's syndrome says, "Most parents who have a baby with Down's syndrome are much older, but I had my baby while I was still quite young. It wasn't what we would have chosen, but now I can be proud of my daughter. Mentally and physically disabled people do have something to offer to the able-bodied. You can learn a lot from someone

with Down's syndrome. My daughter can be very spontaneous, enthusiastic and honest. She can give a lot of love and she's often very happy. She's made my life richer. Of course, life isn't always easy. She needs a lot of care, and sometimes she comes across as very innocent, but you do have to keep a close eye on her."

6

Ecology



BASICS

- 1 What is ecology?
- 2 Feeding relationships
- 3 Cycles
- 4 Pyramids
- 5 Populations
- 6 Ecological succession
- 7 Adaptations in animals
- 8 Adaptations in plants

EXTRA

- 9 Autotrophs and heterotrophs 102
- 10 The energy flow in an ecosystem 103

SUMMARY AND DIAGNOSTIC TEST

- Summary 105
- Diagnostic test 109

EXTENSION

- 1 Ecosystems in the Netherlands 117
- 2 Leaf litter 119
- 3 Living together 120



This unit is called Ecology. This unit teaches you about organisms in relation to their environment. Organisms need nutrients, which they take from their environment. Many organisms themselves serve as food for other organisms. Ultimately all organisms die. However, the substances that they are made from get used again. This unit explains how cycles ensure that substances are not lost.

Over the course of time, species appear with specific adaptations to their environment. You will learn about a number of these adaptations in plants and animals.

When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

1 What is ecology?

The **environment** affects organisms. In turn, organisms also affect the environment. For example, plants give off oxygen to the environment and earthworms make tunnels that loosen up the soil. The part of biology concerning the **relationships** between organisms and their environment is called **ecology**. For example, ecologists are investigating why the number of fish in Dutch waters is falling (see figure 1).

▼ Fig. 1

An ecologist

“Hallo. My name is Bas. I work as an ecologist at a consultancy for water and ecology. Among other things, we investigate the migration of fish. The number of fish species in Dutch waters has decreased dramatically in the twentieth century. Salmon and sturgeon, for example, have disappeared.

Measures have been taken over recent years to prevent overfishing and to reduce pollution. A number of species are doing better now, but this does not apply to migratory fish. They cannot get past the dams and weirs that have been built in rivers.

We are studying measures that will help fish pass a weir or dam. We designed a fish ladder, for example (see photo). We also study the effects of a fish ladder by counting how many fish of each species get past a fish ladder.

In 2012, young sturgeon were released into the Maas and the Waal rivers. If they find their way to the sea and return to the Dutch rivers in a few years to lay

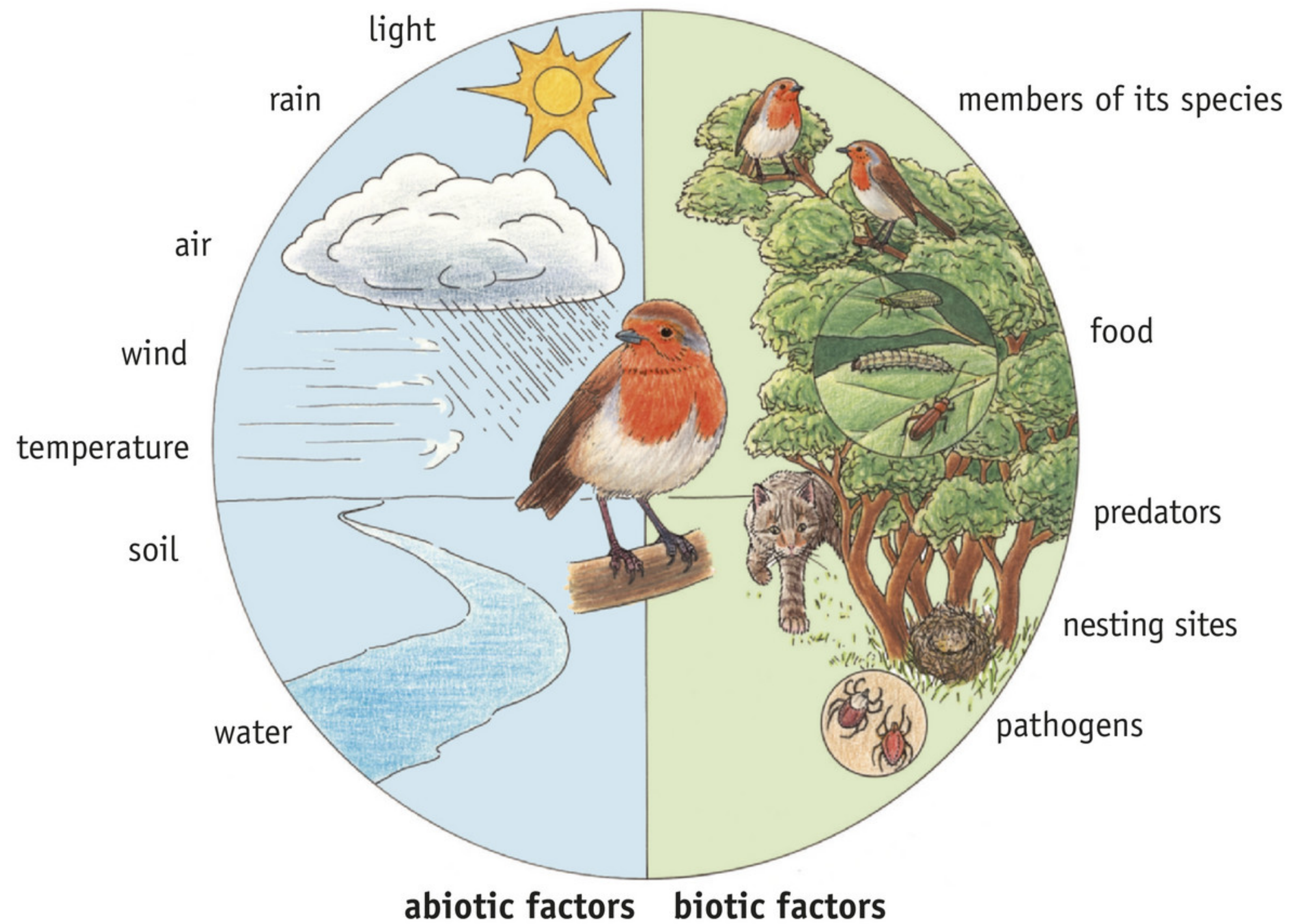
eggs, it will be a sign that things are going well for nature in the Netherlands. If fish stocks improve, this will have a positive influence on animals that eat fish.”



Environmental factors can be categorised into two groups. The influences that come from living nature are called **biotic factors**. These influences come from other organisms. Influences that come from the non-living aspects of nature are called **abiotic factors**. Figure 2 shows biotic and abiotic factors that affect a robin.

WB EXERCISES 1 AND 2, PAGE 46

► **Fig. 2** Biotic and abiotic factors.



THE LEVELS OF ECOLOGY

You learned in year 1 that biology is studied at different levels. It is often important in ecology to know which **level** you are studying (see figure 3). You can investigate the relationships between one **individual** (an organism) and its environment. You could for example investigate the influence of temperature on the growth of one single elephant.

An individual belongs to a certain **population**. A population is a group of individuals of the same species in a given area, which reproduce together. You can also study the relationships between a population and its environment. You could for example investigate the effect of the amount of rainfall on a population of elephants.

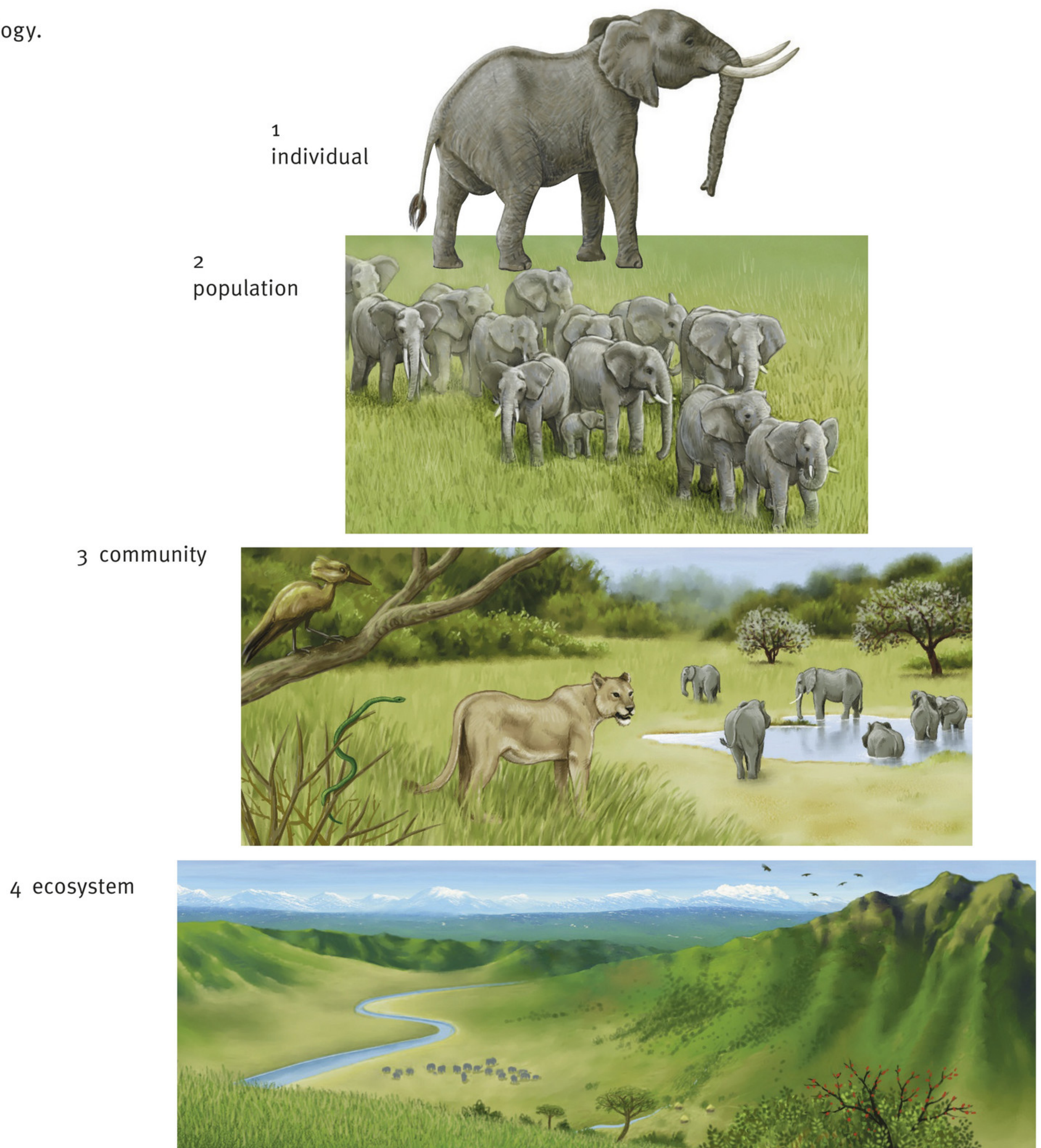
Populations of different species live together in a given area. These populations together make up a **community**. The community of a forest consists of populations of oak and beech trees, bracken ferns, earthworms, shrews, great tits, foxes and many other species.

All the populations in the forest affect each other. In addition, abiotic factors such as temperature, water and soil type also have a significant effect on the forest. All the abiotic factors together in a given area are called the **biotope**. The community and biotope in a forest together form an integral whole. This applies not only to forests but to other areas as well.

An **ecosystem** is a specific area in which the biotic and abiotic factors form a unit. Examples of ecosystems are dune areas, forests, ponds and meadows.

WB EXERCISES 3 AND 4, PAGE 47

► **Fig. 3** The levels of ecology.



2 Feeding relationships

▼ **Fig. 4** A lake.

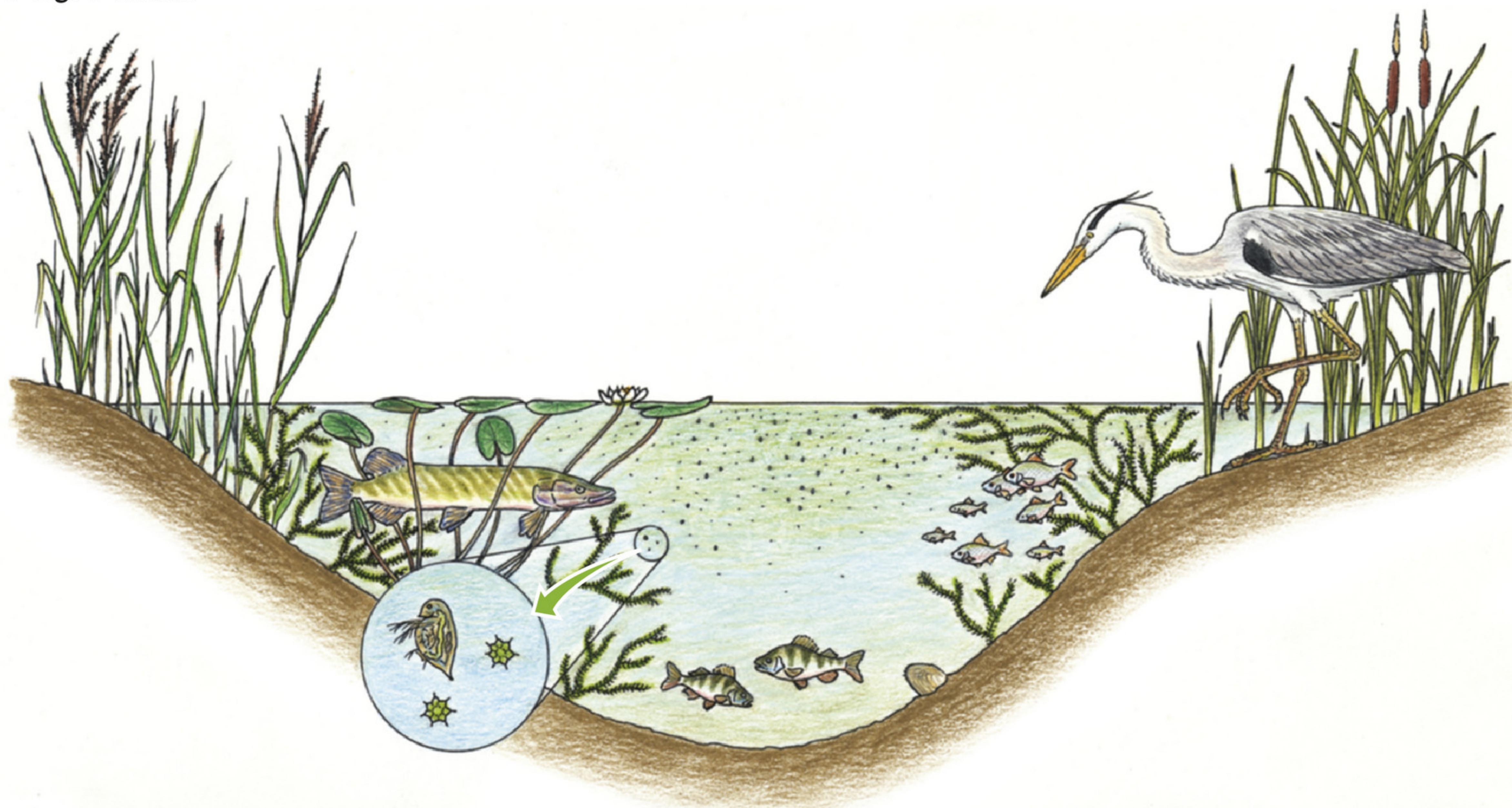
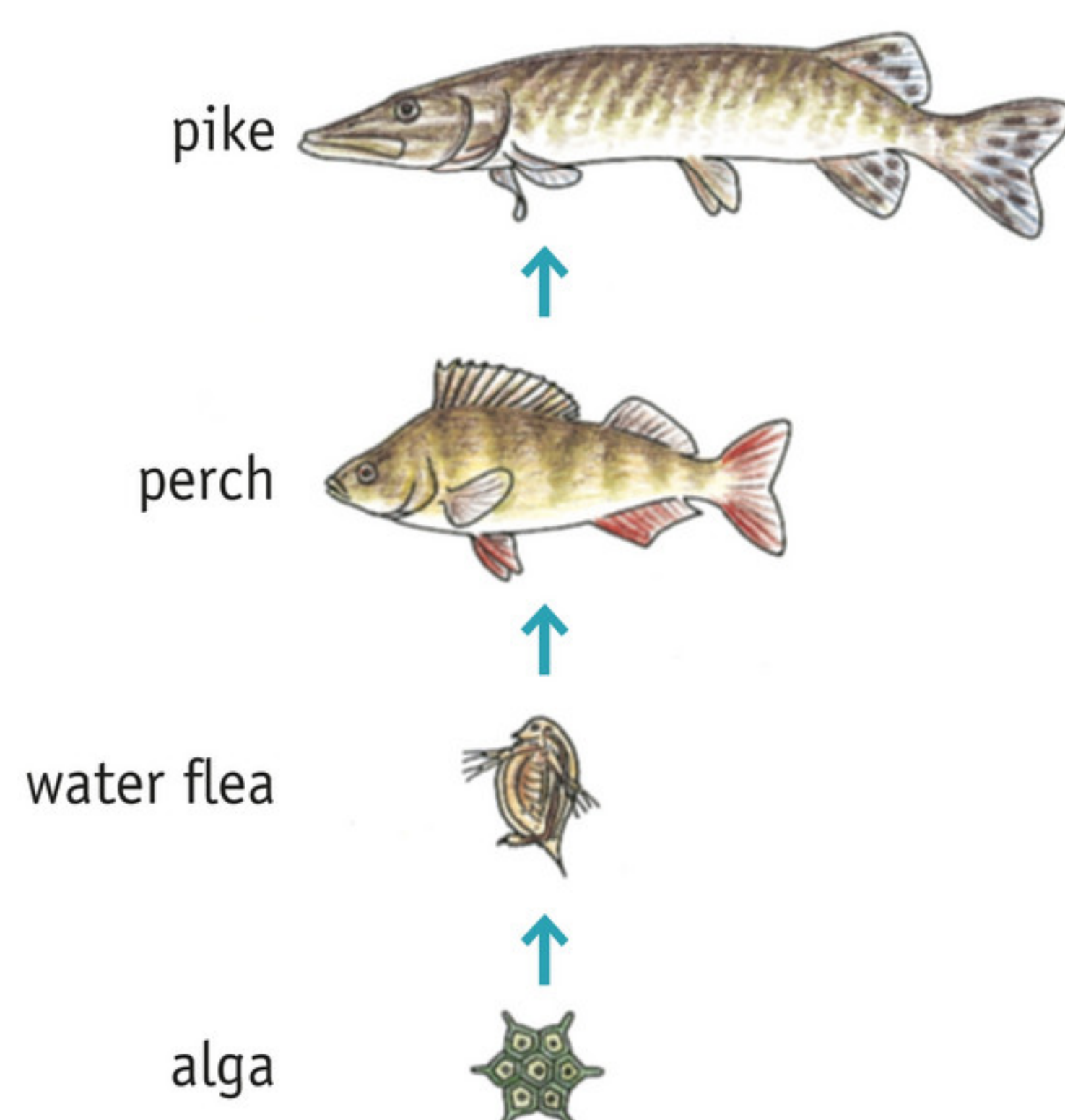


Figure 4 shows a cross-section through a lake with several organisms. The magnified image shows a water flea. Water fleas are **herbivores** (plant eaters). They eat algae. It also shows perch. Perch eat water fleas. They are **carnivores** (meat eaters). It also shows a pike. Pikes eat – among other prey – perch. Algae, water fleas, perch and pike make up a **food chain** (see figure 5). A food chain is a series of organisms in which each organism is the food source for the next. The first link of the food chain in figure 5 is a plant species. From there, an arrow points to the second link: a herbivore. From the herbivore, an arrow can then point to the third link: a carnivore.

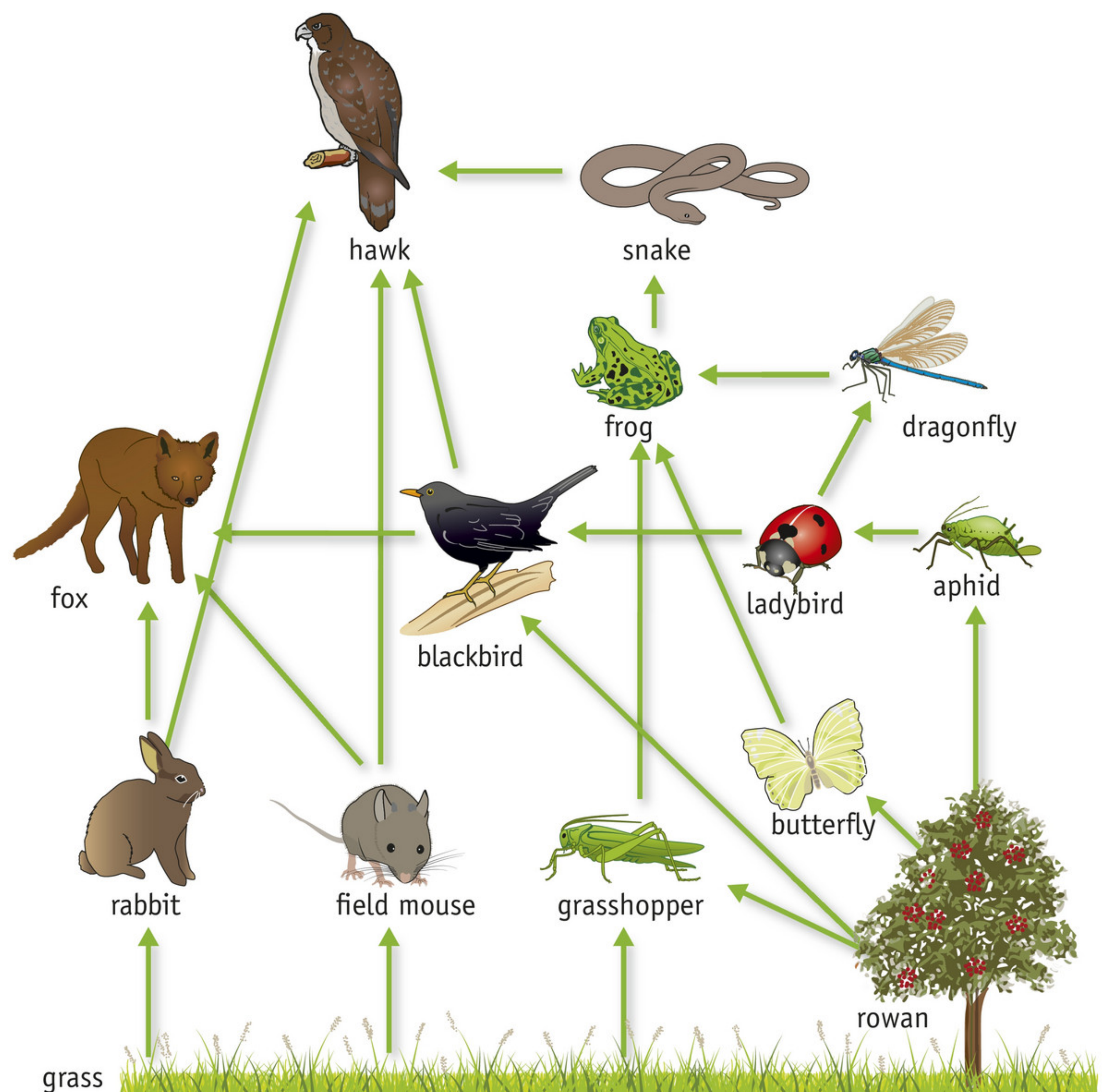
▼ **Fig. 5** A food chain.



In reality an ecosystem never only contains a single food chain. Each species can serve as food for many other species. In an ecosystem, the food chains are interrelated and form a network. All the feeding relationships in an ecosystem are called a **food web**. Figure 6 is a drawing of a food web. As well as herbivores and carnivores, a food web also contains **omnivores** (that eat both plants and animals). One example of an omnivore is a blackbird (see figure 7).

WB EXERCISES 5 TO 7, PAGE 49

► **Fig. 6** A food web.



► **Fig. 7** A blackbird is an omnivore.



1



2

▼ Fig. 8 Consumers.



1 herbivore (cow)



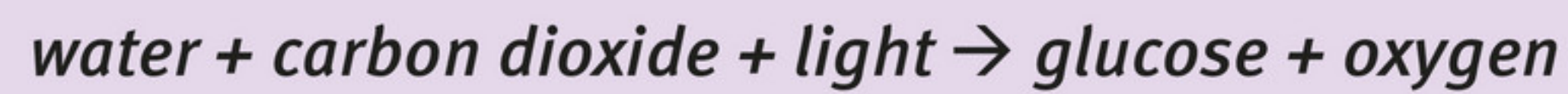
2 carnivore (osprey)



3 omnivore (human)

PRODUCERS, CONSUMERS AND DECOMPOSERS

In part 1, you learned that plants photosynthesise. You can describe photosynthesis in an equation:



The glucose made by photosynthesis is used by the plant to produce the substances that it is made of. The plant also needs **minerals** (nutrients from the ground) to do this. Plants provide the food for other organisms. That is why we call plants **producers**. Producers are always the first link in a food chain.

Animals eat (consume) the substances made by plants. That is why we call animals **consumers**. Animals are the second and subsequent links in a food chain. Herbivores are the second link in a food chain and carnivores are the third and later links. In a food chain, the producers get eaten by the **primary consumers**. They in turn get eaten by **secondary consumers**, and so forth.

Not all plants and animals get eaten. They can also simply die. The dead remains of plants and animals are then used as food by **scavengers** (see figure 9). The remains left by the scavengers are broken down by bacteria and fungi. That is why bacteria and fungi are called **decomposers**.

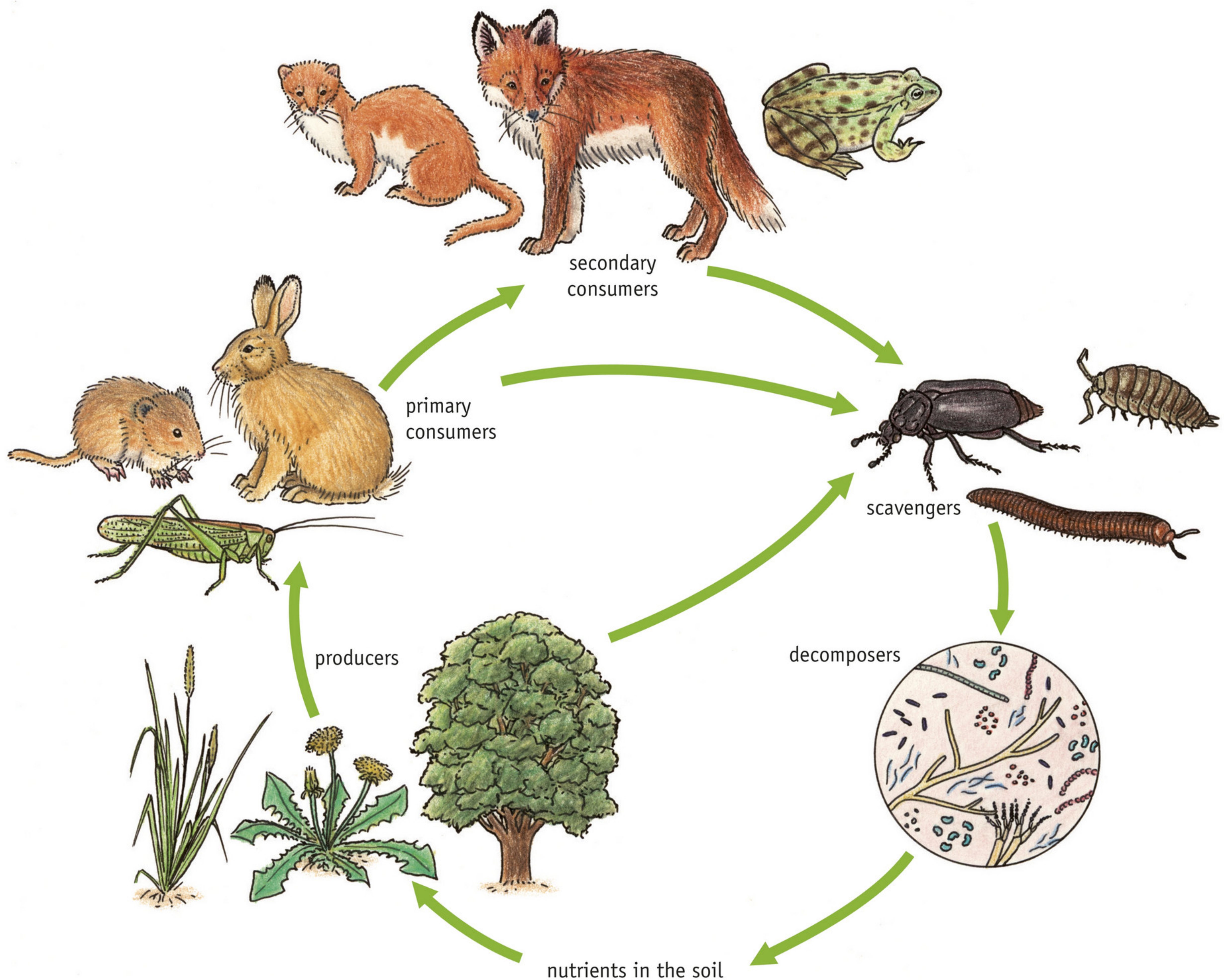
▼ Fig. 9 Scavengers.



Decomposers convert the substances from the dead remains of organisms into carbon dioxide, water and minerals. Carbon dioxide and water can in turn be absorbed by producers and used in photosynthesis. The minerals can also be absorbed by producers. The substances from the plants eventually end up in plants again, via animals, scavengers, bacteria and fungi. In nature, all substances are recycled in this **nutrient cycle** (see figure 10).

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▼ Fig. 10 The nutrient cycle.



3 Cycles

In an ecosystem, every substance goes through its own cycle. In this basics section, you will learn about the water and carbon cycles.

THE WATER CYCLE

All organisms need water to live. You take in water when you drink or eat. Water leaves your body through urine or sweat. In unit 1 (Breathing and respiration), you learned that water also leaves your body when you breathe out, as water vapour.

In nature, water goes through a cycle. Most of the water is found in the oceans and seas. Together they cover about 75% of the Earth's surface (see figure 11). Water **evaporates** from the oceans and seas, especially when the weather is warm. The **water vapour** that is formed then rises. It cools down as it goes, causing **condensation** to occur. Small droplets of water appear, forming clouds. When the droplets in the clouds get big enough, it starts to rain. Or if the temperature is very low, snowflakes or hailstones may form.

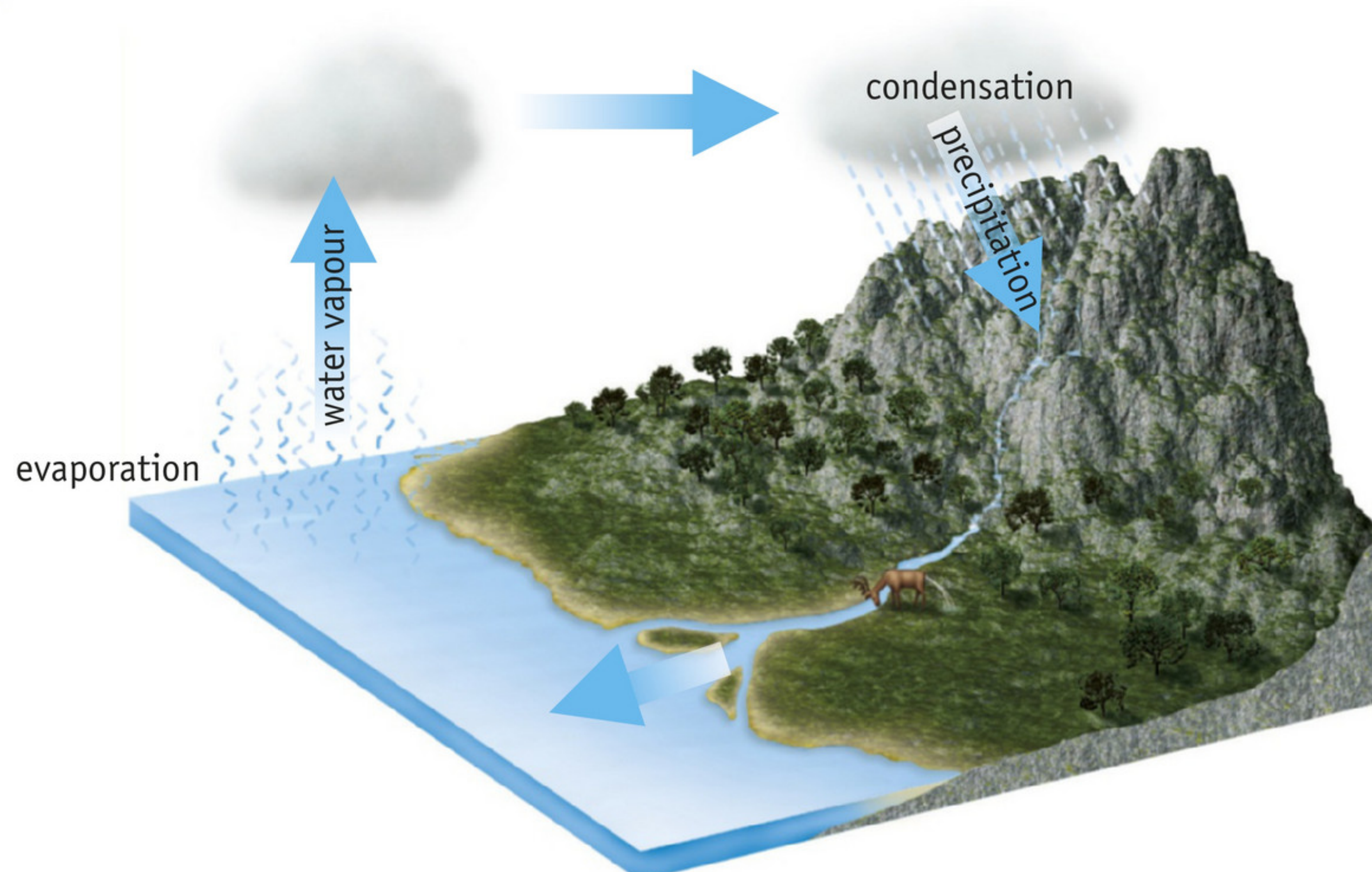
Water that has evaporated from the oceans and seas returns back to the surface of the Earth as **precipitation** (rain, snow or hail). The water gathers in rivers and flows back into the oceans and seas. And so the water cycle is complete (see figure 12).

▼ **Fig. 11** Oceans and seas cover about 75% of the Earth's surface.



WB EXERCISE 11, PAGE 54

▼ **Fig. 12** The water cycle.



THE CARBON CYCLE

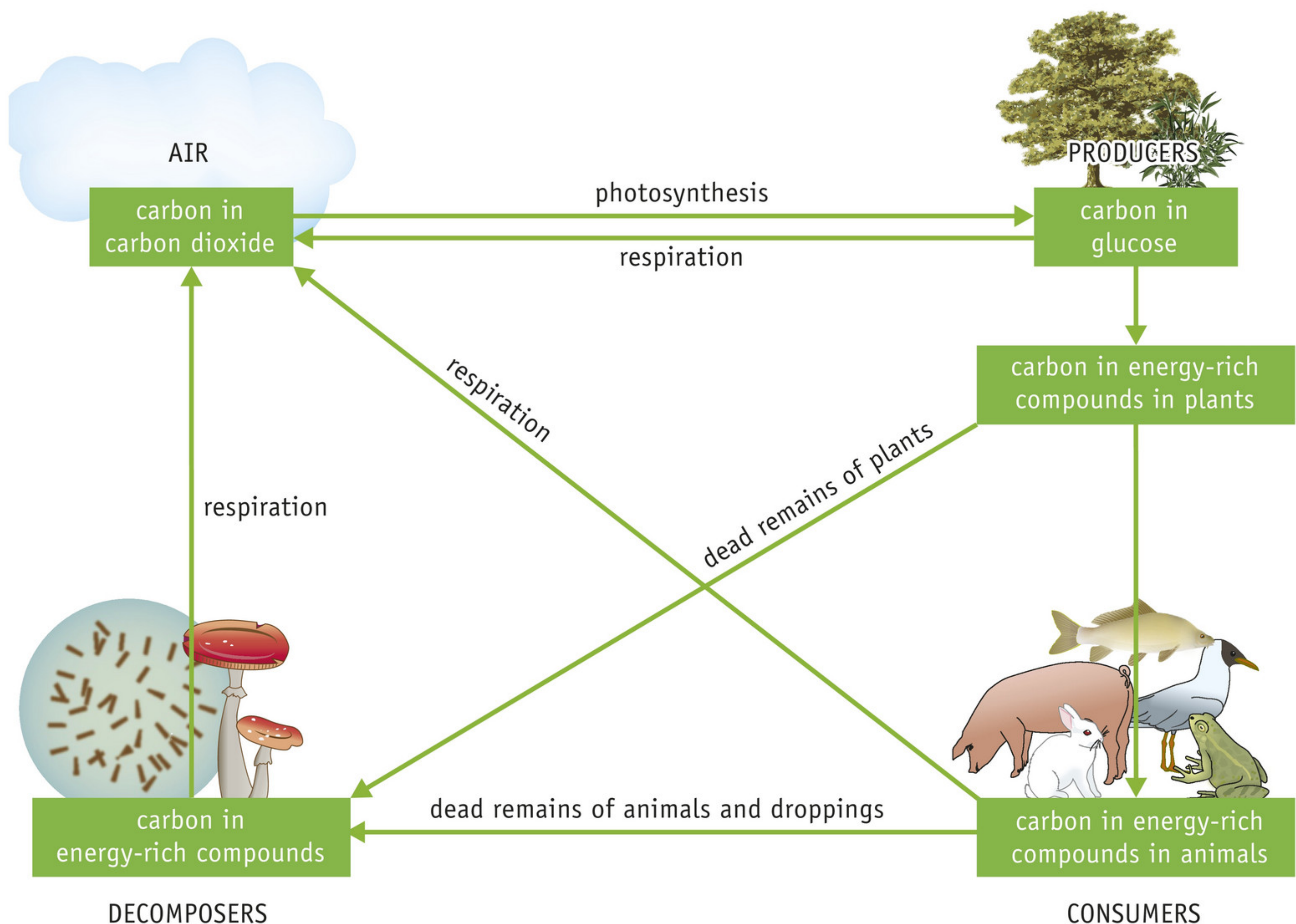
Figure 13 is a diagram of the carbon cycle. This figure shows the forms in which carbon is present in the air, in plants, in animals and in bacteria and fungi.

The air contains **carbon dioxide** gas. Carbon dioxide molecules are made up of oxygen and carbon atoms. Plants (producers) absorb carbon dioxide from the air in photosynthesis. This creates **glucose** and oxygen. The atoms in glucose molecules include carbon atoms from carbon dioxide.

Glucose is an energy-rich compound. In unit 1 (Breathing and respiration), you learned that your body uses glucose as fuel. It releases the energy in glucose during the process of respiration. You need this energy for life processes such as moving and maintaining your body temperature.

Plants use some of the glucose they produce themselves. In cells with no chlorophyll and in the dark, glucose is burned to release energy. This produces carbon dioxide, which the plants release to the air. The plant uses another fraction of the glucose produced to make various energy-rich compounds (carbohydrates, proteins and fats). This is how carbon atoms end up in energy-rich compounds in plants.

▼ **Fig. 13** The carbon cycle (schematic).



When a plant gets eaten by an animal, the energy-rich compounds from the plant get transferred to the animal. A proportion of these compounds are used as fuel in the body cells of the animal. This also produces carbon dioxide, which is released to the air. Another fraction of the energy-rich compounds are used as building materials. The carbon is now in the energy-rich compounds of animals (carbohydrates, proteins and fats). Finally, some of the plant compounds are not digested; this fraction leaves the body of the animal through its droppings (see figure 14).

In turn, an animal may be eaten by another animal or by a human. This is how the carbon of one organism can end up in another organism.

Plants and animals also die without getting eaten. The substances in the dead remains of organisms and in the droppings of animals are absorbed by bacteria and fungi (decomposers). Bacteria and fungi use most of the energy-rich compounds they absorb as fuel in respiration. This produces carbon dioxide again, which is released to the air. Bacteria and fungi clean up the dead remains of organisms and release the carbon from these dead remains back into the air (see figure 15).

WB EXERCISES 12 TO 14, PAGE 55

▼ **Fig. 14** Some plant compounds leave the body of an animal in its droppings.

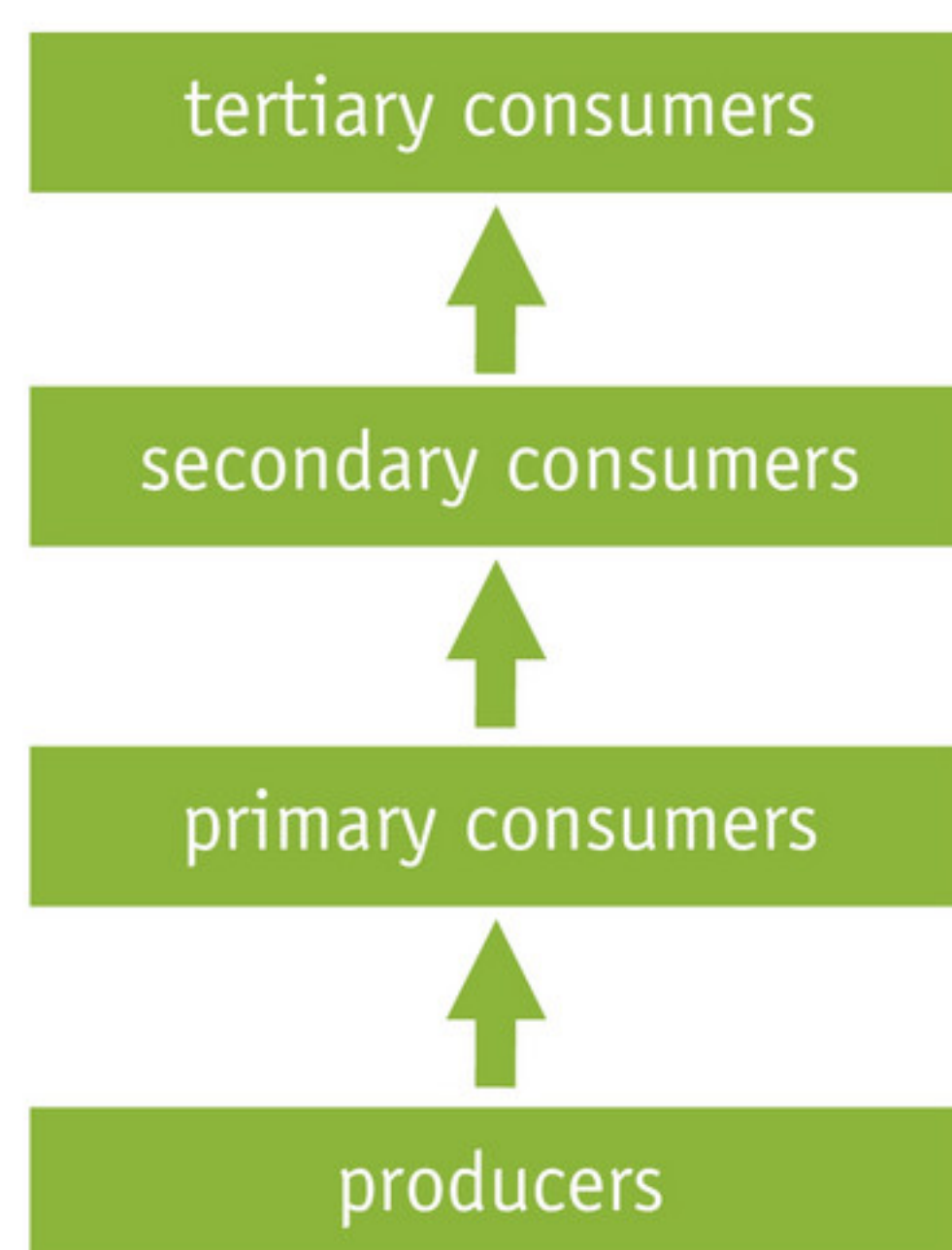


▼ **Fig. 15** Degradation by decomposers releases carbon dioxide into the air.



4 Pyramids

▼ **Fig. 16** A food chain.

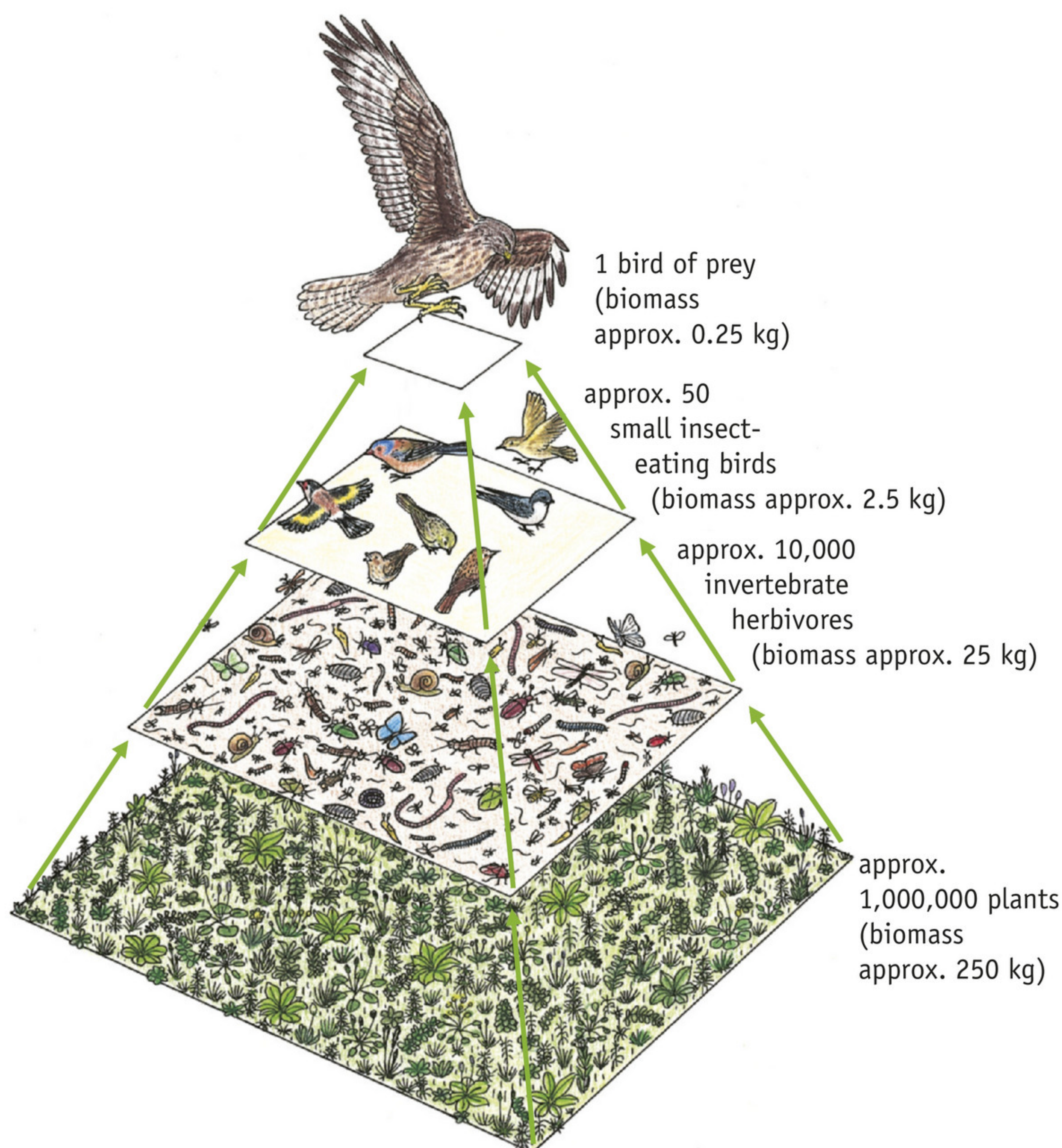


In an ecosystem, all the feeding relationships taken together form a food web. A food web like this is usually too complicated to study in detail. But dividing all organisms in an ecosystem into producers, primary consumers, secondary consumers and so forth, gives you a simpler food chain (see figure 16). This is a lot easier to study.

PYRAMIDS OF NUMBERS

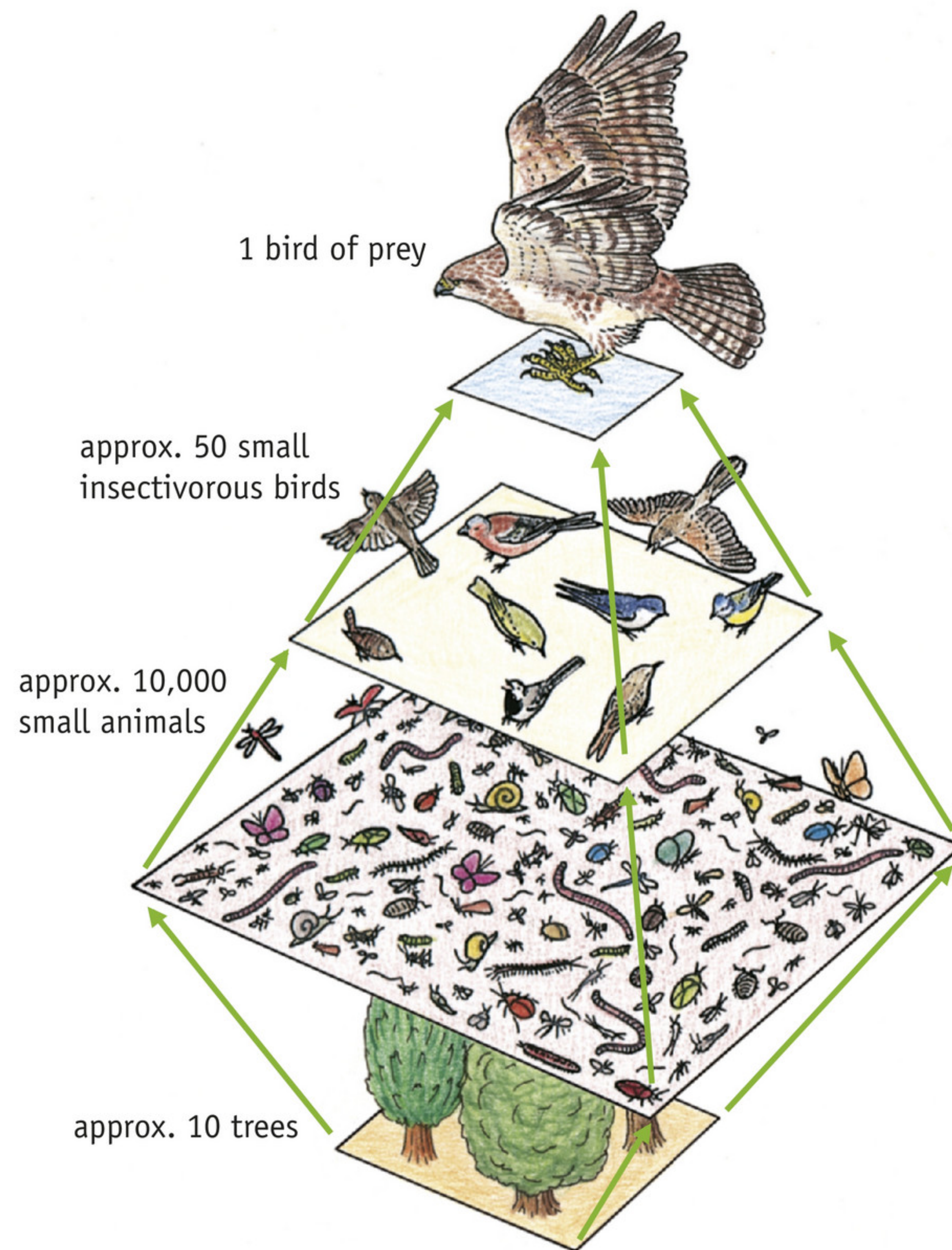
A food chain consists of a sequence of species of organisms. The number of organisms decreases in each link of the food chain. The number of individuals in each link of a food chain can be shown in a **pyramid of numbers**. Figure 17 shows a schematic drawing of such a pyramid.

▼ **Fig. 17** A food chain, shown as a pyramid.

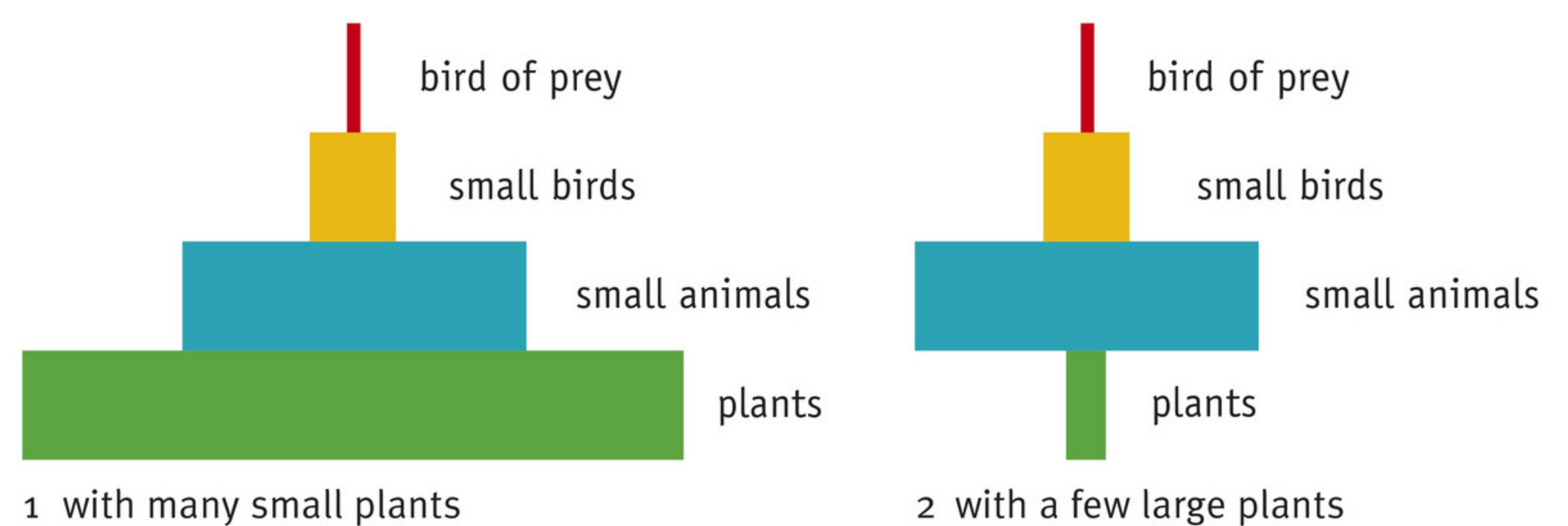


The number of individuals in each subsequent link of a food chain does not always decrease, though. For example, the number of trees in a forest is much smaller than the number of herbivores (snails, caterpillars, beetles, etc.), but the numerous herbivores do serve as food for a smaller number of birds. Figure 18 shows one such non-standard pyramid of numbers. Pyramids of numbers are often drawn schematically as in figure 19.

▼ **Fig. 18** A pyramid of numbers does not always have a pyramid shape.



► **Fig. 19** Pyramid of numbers.



PYRAMIDS OF BIOMASS

Every organism is made up of many different substances. A number of these substances are rich in energy, such as carbohydrates, proteins and fats. The total mass of all the energy-rich compounds in an organism is called the **biomass** of that organism.

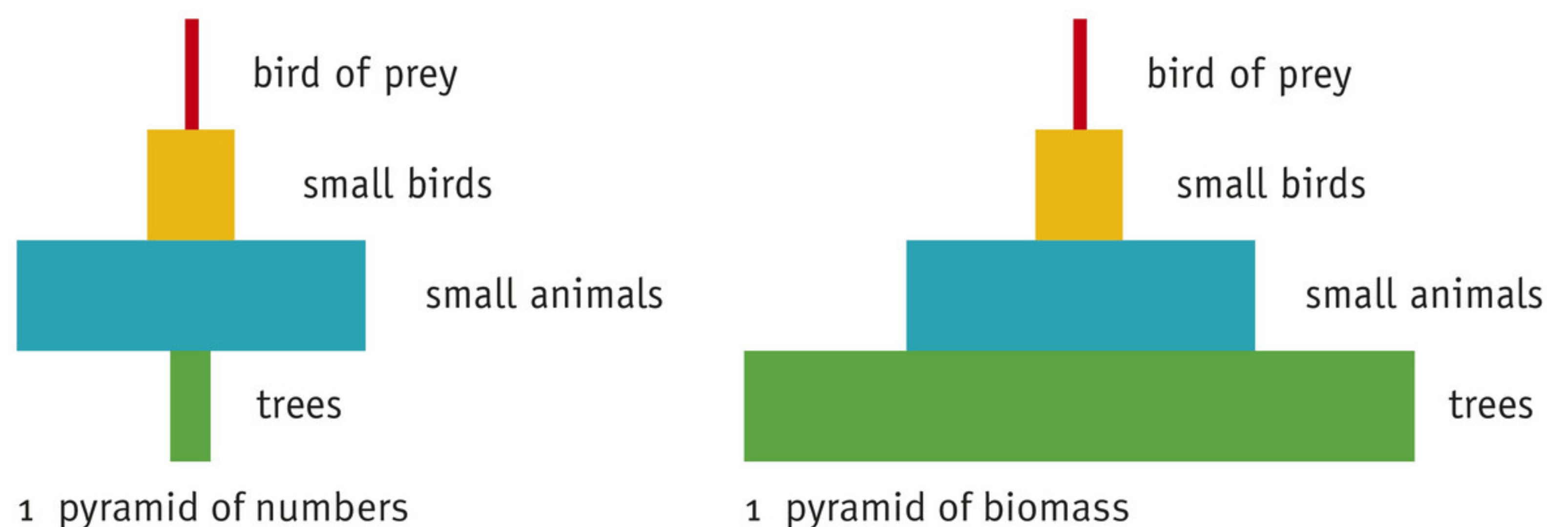
You can also calculate how much biomass there is in each link of a food chain. You do that by calculating the biomass of all organisms in a link together. Figure 17 shows the biomass of each link. This figure shows that the biomass of plants at the bottom of the pyramid is much larger than the biomass of the herbivores above it. That biomass is in turn larger than that of the insect-eating birds, and so forth.

The **pyramid of biomass** shows the biomass of each link of a food chain. It always has a pyramid shape. Figure 18 showed you that the pyramid of numbers can have a different shape. In figure 20, though, you can see that in these ecosystems the pyramid of biomass also has a pyramid shape.

The biomass at each subsequent level of a food chain decreases.

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► **Fig. 20** Pyramids of the same food chain.



5 Populations

The population of a particular species in an ecosystem is not always the same size. Under favourable conditions a population can grow, and in unfavourable conditions it may shrink (see figure 21). When all the biotic and abiotic factors are at their most favourable, we refer to it as the **optimum conditions**. The probability of a population growing is then at its maximum.

Individuals can die because of unfavourable circumstances. This may happen even if only one factor is unfavourable, and the probability that a population will then shrink is high.

▼ Fig. 21

Game butcher

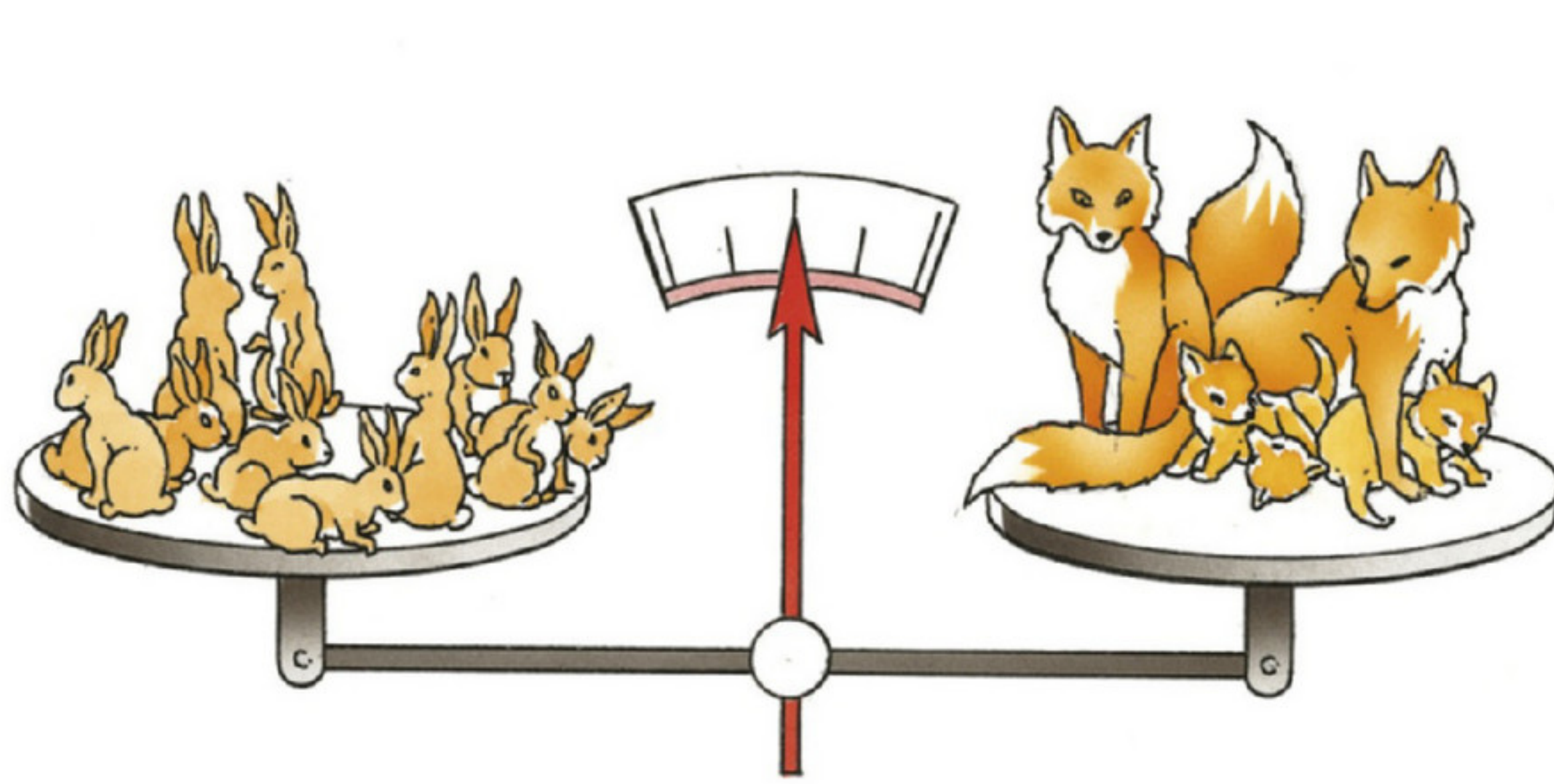
Hello. My name is Wijnand and I am a butcher specialising in game. Most other butchers order what they need from an abattoir. For me it is different. I depend on the amount of game, which is not the same every year. I prefer to buy game that was hunted in the Netherlands, but sometimes I have to buy game from other countries.

One of the animals I sell the meat of is wild boar. Wild boars find their food by rooting in the ground. They find all sorts of things, such as roots, nuts and various insects. Their most important food sources are acorns and beech nuts. In an average year, five million kilos of these fruits falls to the ground. But sometimes, such as in 2014, the amount is much less. This will mean less food is available, so fewer young wild boars will become adults. There will be fewer wild boars the year after that. Wild boars are not allowed to be hunted as much then, and so the amount of boar meat that I can buy also decreases. There are also years in which more such fruit falls to the ground. No less than ten million kilos fell in 2000. The year after that, I was able to buy a lot of wild boar meat.



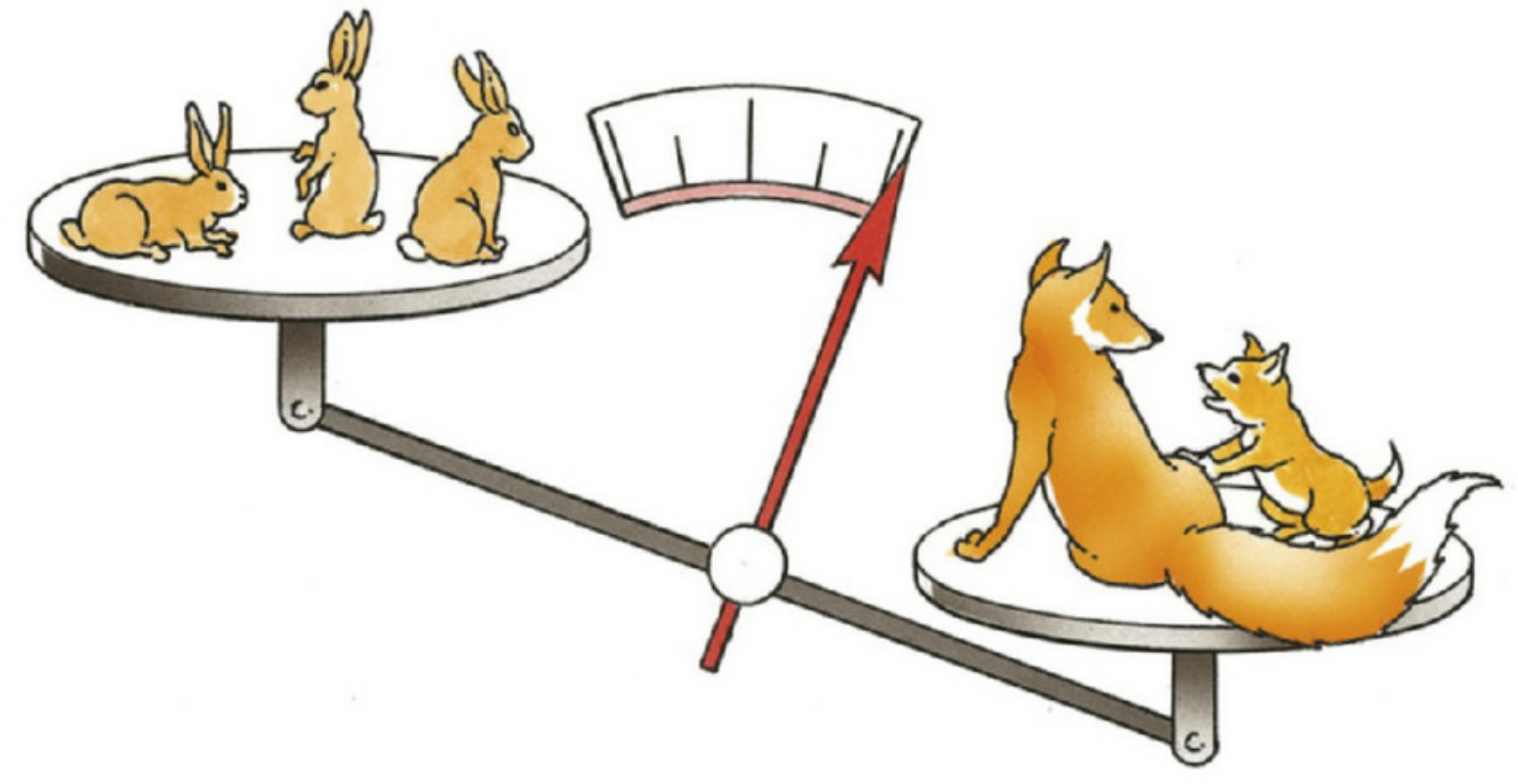
In many ecosystems populations sometimes grow and then shrink again. In most cases, the **population size** fluctuates around an equilibrium value. We call that a **biological equilibrium**. Figure 22 is a schematic drawing of the biological equilibrium between rabbits and foxes.

▼ **Fig. 22** Biological equilibrium between rabbits and foxes (schematically).



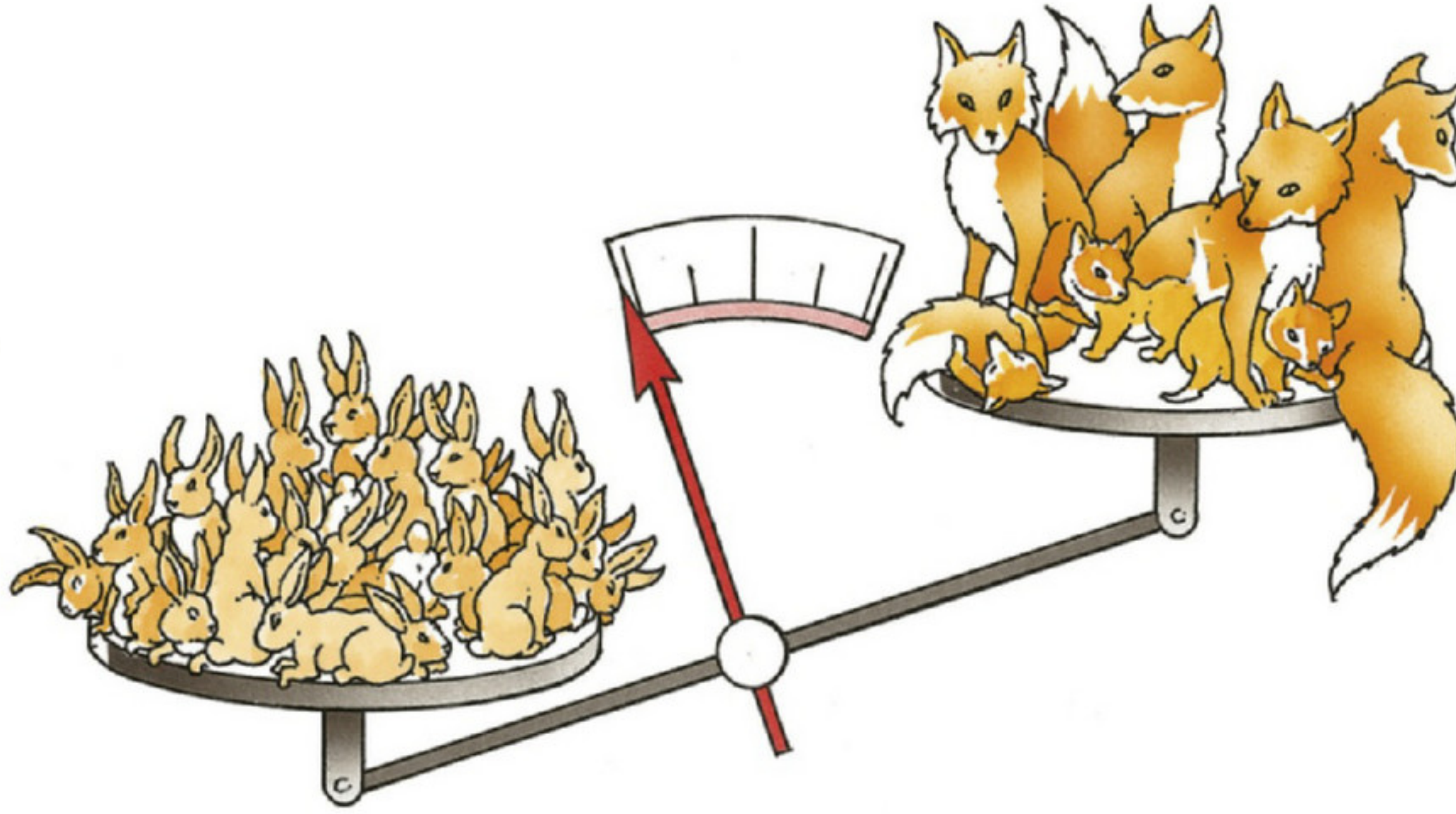
1st year

- normal weather conditions: equilibrium



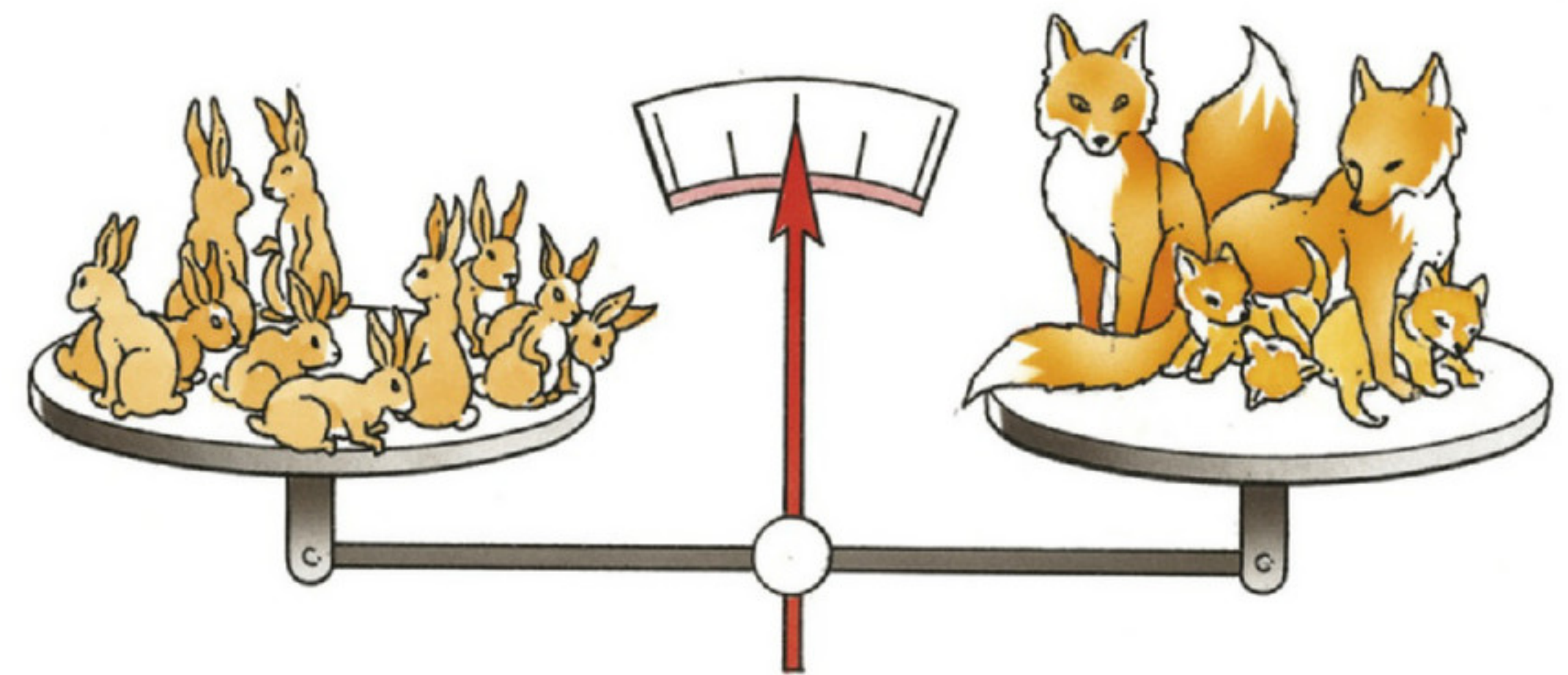
2nd year

- grass grows poorly due to low temperatures and drought
- rabbits die due to lack of food
- foxes move to other ecosystems
- the foxes that remain do not have as many young



3rd year

- grass grows fast in hot and damp weather conditions
- rabbits have a lot of young
- foxes from elsewhere migrate into the ecosystem



4th year

- normal weather conditions: equilibrium

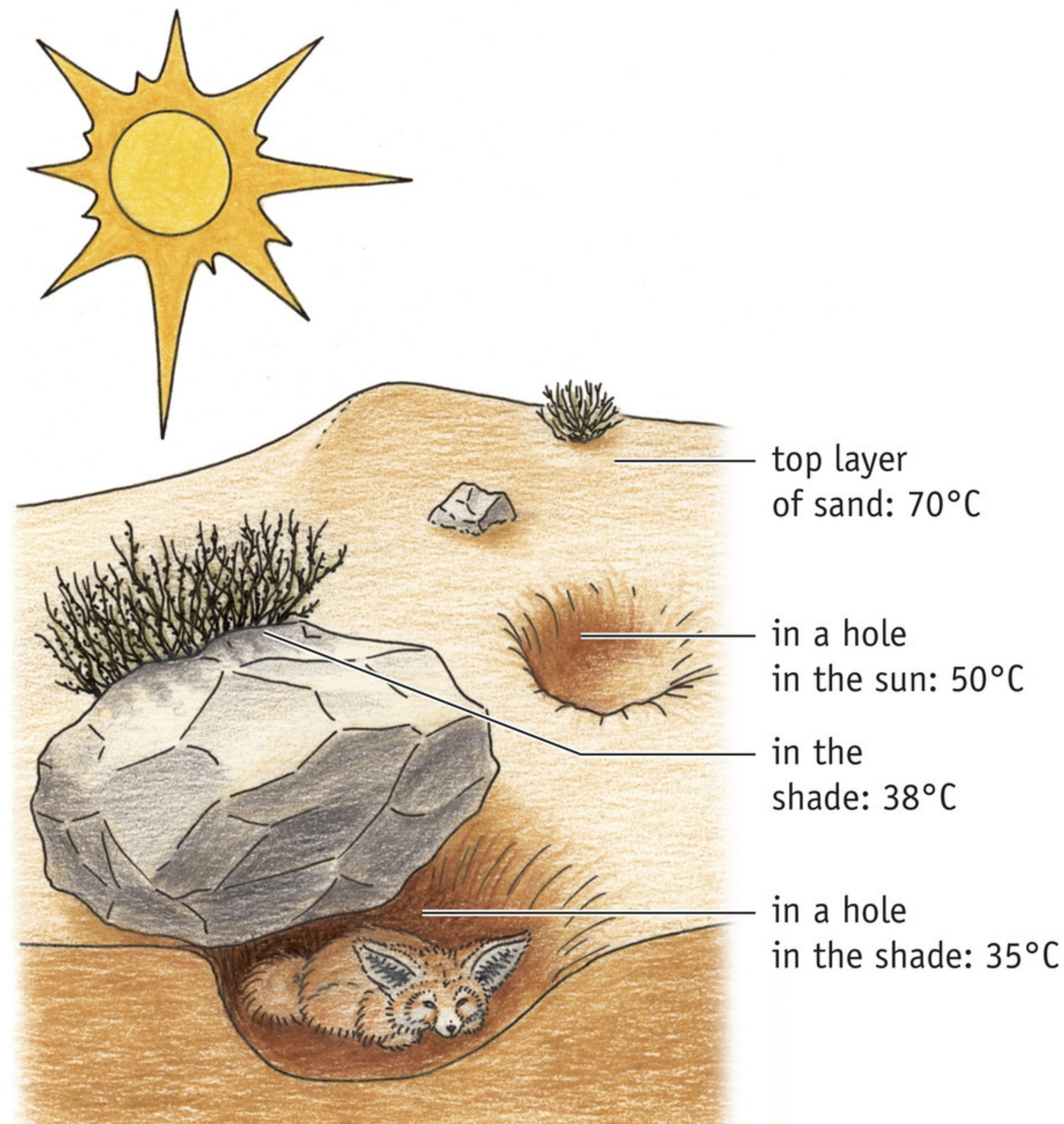
CLIMATE

Various biotic and abiotic factors affect the size of a population. Examples of biotic factors are the amount of food available, the number of natural predators and the pathogens present. Examples of abiotic factors are soil condition, temperature, light, air (wind) and water (precipitation). The last four factors together form the **climate**.

Plants and animals usually have adaptations to suit the climate in which they live. These adaptations appeared over the course of evolution. Polar bears are adapted to the cold, for instance, and cacti to drought.

The conditions in an ecosystem can vary a great deal. Plants and animals must therefore be able to tolerate fluctuations in the abiotic factors. The air temperature in a desert can vary by as much as 50°C between day and night. Desert plants have to be able to tolerate these fluctuations. Desert animals can avoid the worst of the fluctuations by hiding in a sheltered place (see figure 23).

► Fig. 23



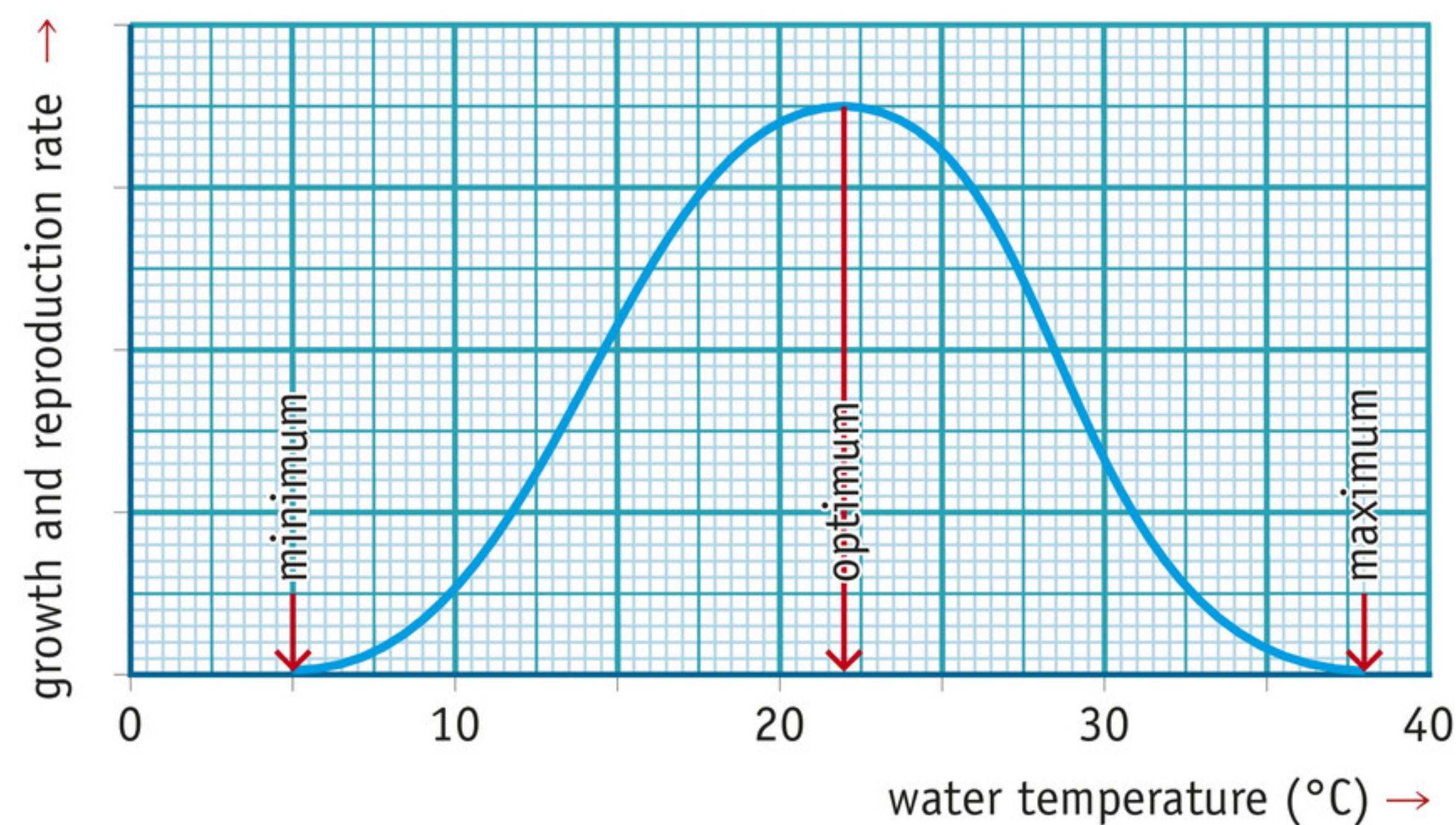
▼ Fig. 24 Guppies.



Each organism can only tolerate fluctuations in the temperature of the environment up to a certain extent. Guppies are tropical fish that are often kept in aquariums (see figure 24). Guppies cannot survive at temperatures below 5°C. This is the minimum temperature for guppies. They also cannot live at temperatures above 38°C. This is the maximum temperature for guppies. Guppies have the greatest chance of staying alive and having offspring at a temperature of 22°C. Figure 25 is a graph showing the relationship between the water temperature and the growth and reproduction rate in guppies. This graph is known as a **tolerance curve**.

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► Fig. 25 The relationship between the temperature and the growth and reproduction rate in guppies.



6 Ecological succession

▼ Fig. 26

You can often see piles of sand in newly built districts. If these piles are not removed, plants will eventually start growing on them. A few years later you will find dense vegetation (see figure 26).

A big pile of sand in a new district

Liedsche Rijn, now a suburb of Utrecht, used to be the largest new housing development site in the Netherlands. A great deal of sand is needed for the construction of roads and houses. You can often see piles of sand at new housing developments (see top photograph). If these 'dunes' are left alone for a while, they get covered in vegetation. One of the first plants to grow on such a pile of sand is oilseed rape (see bottom photograph). Grass and poppies are also able to cover bare areas of land quickly. If such a dune remains in place for several years, more and more species will grow on it. The yellow of the oilseed rape disappears and bushes and young trees appear instead.



Even a bare piece of rock gets covered with vegetation, although very slowly. Wind, rain and frost **weather** the rock. Grit forms in the crevices and cracks in particular. The wind carries small soil particles that get mixed in with the grit. This subsoil is enough for lichen to grow (see figure 27). The first small animals soon get established in amongst the lichens. An ecosystem has now formed on the piece of rock.

► Fig. 27 A bare piece of rock becomes covered with lichen.



PIONEER COMMUNITY

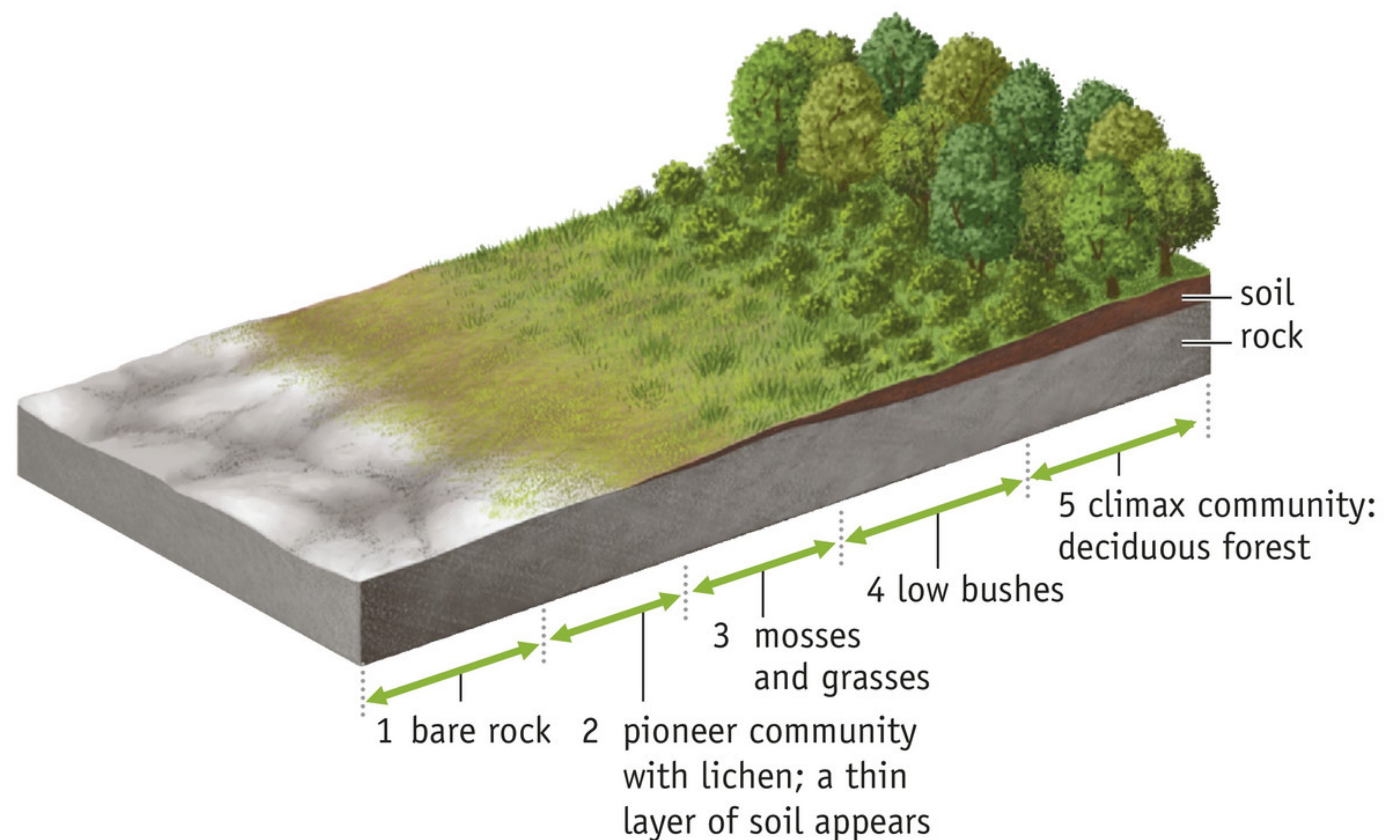
The first ecosystem that appears on barren terrain is called a **pioneer community**. A pioneer community only has a few different species of plants and animals. There are many individuals of the species that live there, but because there are only a few different species the food web is simple.

Once a rock has been covered in lichen, the conditions become more favourable. The rock will then get less hot when exposed to the sun. When lichens die, a little bit of **humus** is left on the surface. Humus consists of more or less decayed dead remains plus decomposers (bacteria and fungi). This means that humus contains a lot of minerals.

Moss and some herbaceous plants (such as grasses) can grow on a thin soil layer that contains humus. The environment slowly becomes less favourable for the lichens and more favourable for other plants. The lichens disappear and different species of plants take their place. As a result, other animal species also settle there.

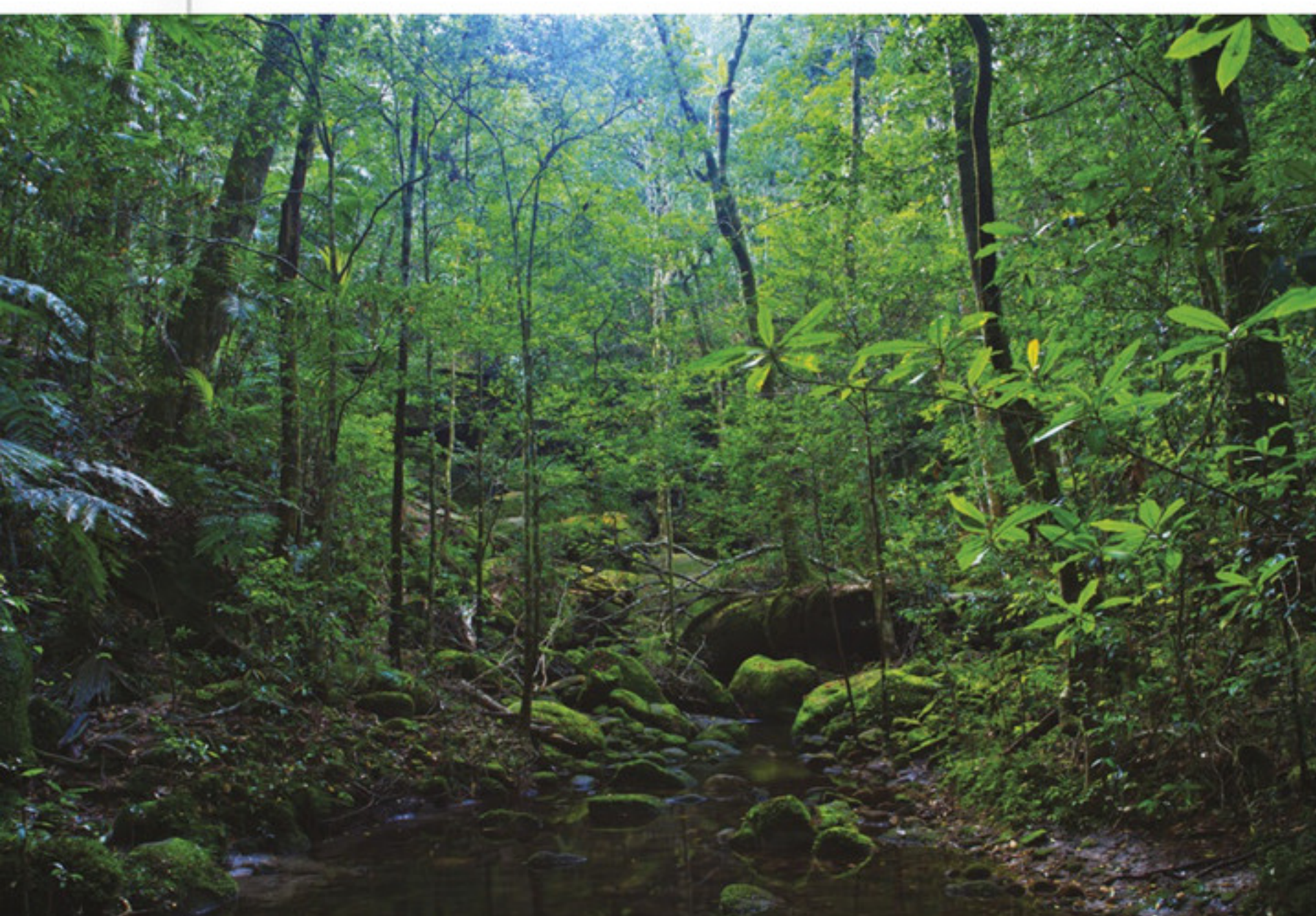
The roots of plants speed up the weathering of the piece of rock. The dead remains of plants produce more humus. In addition, the abiotic factors become more moderate. During the day it becomes less hot in the shade of the plants, and at night the plants retain the heat. This makes the terrain more suitable for more and more different species of plants and animals. The species of plants and animals in a given area change gradually over time. We call this process **succession** (see figure 28).

► **Fig. 28** Succession on bare rock.



the successive stages are drawn next to each other

▼ **Fig. 29** A climax community is rich in species.



CLIMAX COMMUNITY

Succession can lead to a final stage in which the abiotic factors are more or less constant. The existing plant and animal species are no longer replaced by other species. This final stage is called a **climax community**. A climax community is usually rich in species. This makes the food web more complex. Examples of climax communities are rainforests in the tropics and deciduous forests in the Netherlands.

7 Adaptations in animals

Animals have **adaptations** to the biotope in which they live. These adaptations can be focused on various life processes, such as moving, feeding, respiration or reproduction.

AQUATIC ANIMALS AND TERRESTRIAL ANIMALS

Animals that live in water (aquatic animals) have different characteristics to animals that live on land (terrestrial animals). Fish, for example, have organs that do not occur in land animals, such as gills and fins. A fish swims forward by moving back and forth through the water, using the tail fin in particular. The other fins are used by the fish to stay upright in the water. The skin is covered in scales with a layer of slime on top. This mucus makes the skin very slippery. As a result, the water resistance is low when the fish is swimming. The body shape also reduces water resistance. The head gradually transitions into the torso and then the tail. We call this body shape **streamlined**. Birds and mammals that live in water are also streamlined (see figure 30).

▼ **Fig. 30** Animals that live in water.



1 shark (a fish)

2 penguin (a bird)

3 dolphin (a mammal)

▼ **Fig. 31** Animals that live on land.



1 squirrel (a mammal)



2 emu (a bird)

Animals that live on land have other body shapes (see figure 31). Terrestrial animals have more problems coping with their own weight than aquatic animals. Aquatic animals float in the water; they can be 'supported' by the water. You may have noticed this yourself in a swimming pool. It is easy to lift someone with one hand when you are under water, no matter how heavy they are. But you cannot do this on land. Land animals often have adaptations to carry their own weight, such as strong legs and a sturdy skeleton.

WB EXERCISE 23, PAGE 64

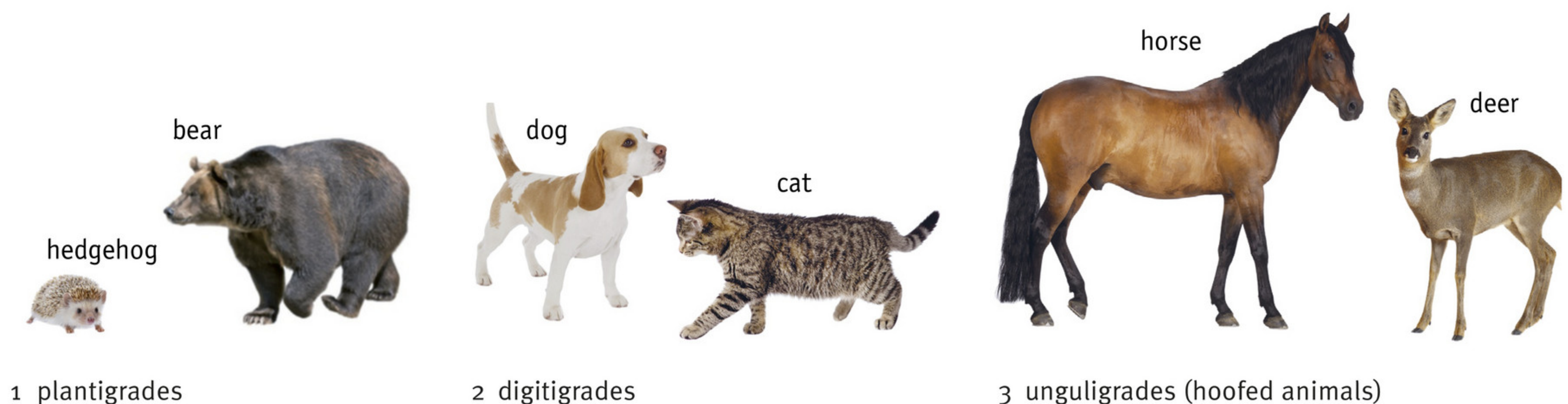
THE LEGS OF LAND MAMMALS

The resistance of the ground is very important for the motion of land animals. You will probably have noticed that you can run much faster on hardened roads than on loose sand or mud. The legs of land animals are adapted to the ground surface. When the ground is hard, animals benefit if only a small part of the foot touches the ground. The resistance of the ground when walking or running is then as low as possible. But when the ground is soft, animals benefit from being able to walk on their entire foot, because they will not sink into the soft ground as easily then.

In part 1, you learned that mammals can be classified into **plantigrades**, **digitigrades** and **unguligrades** (see figure 32). In unguligrades, not all of the toes develop. Pigs develop four toes and deer develop two. Horses only develop one toe. Of each toe that does develop, only the last phalanx touches the ground. This phalanx is surrounded by a hoof made of keratin. That is why unguligrades are sometimes also called **hoofed animals**.

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▼ Fig. 32 Plantigrades, digitigrades and unguligrades (hoofed animals).



BIRDS' LEGS

Birds' legs also have characteristics that make them suitable for their role. You can see a number of examples of this in figure 33.

Birds that live in trees and bushes must be able to hold on to branches. Their feet make this possible. Of the four toes, three point forwards and one points backwards. Feet like these can be seen in **songbirds** (such as blackbirds, starlings, tits and finches).

Birds of prey (such as buzzards, falcons and owls) have toes with sharp claws. The birds use these claws to catch their prey. **Flightless birds** (such as ostriches) never sit on branches. These birds have long legs with toes that point forwards. **Water birds** (such as ducks and swans) have webbed feet so that they can swim easily. **Waders** (such as lapwings, oystercatchers and curlews) search for food in shallow water or mud. These birds have long legs so that the torso remains dry. They also have long toes so that they do not sink into mud as easily.

▼ Fig. 33 Birds' legs.



1 a finch has legs for perching on twigs and branches

2 a buzzard has legs with claws

3 an ostrich has legs made for running

4 a duck has legs with webbed feet

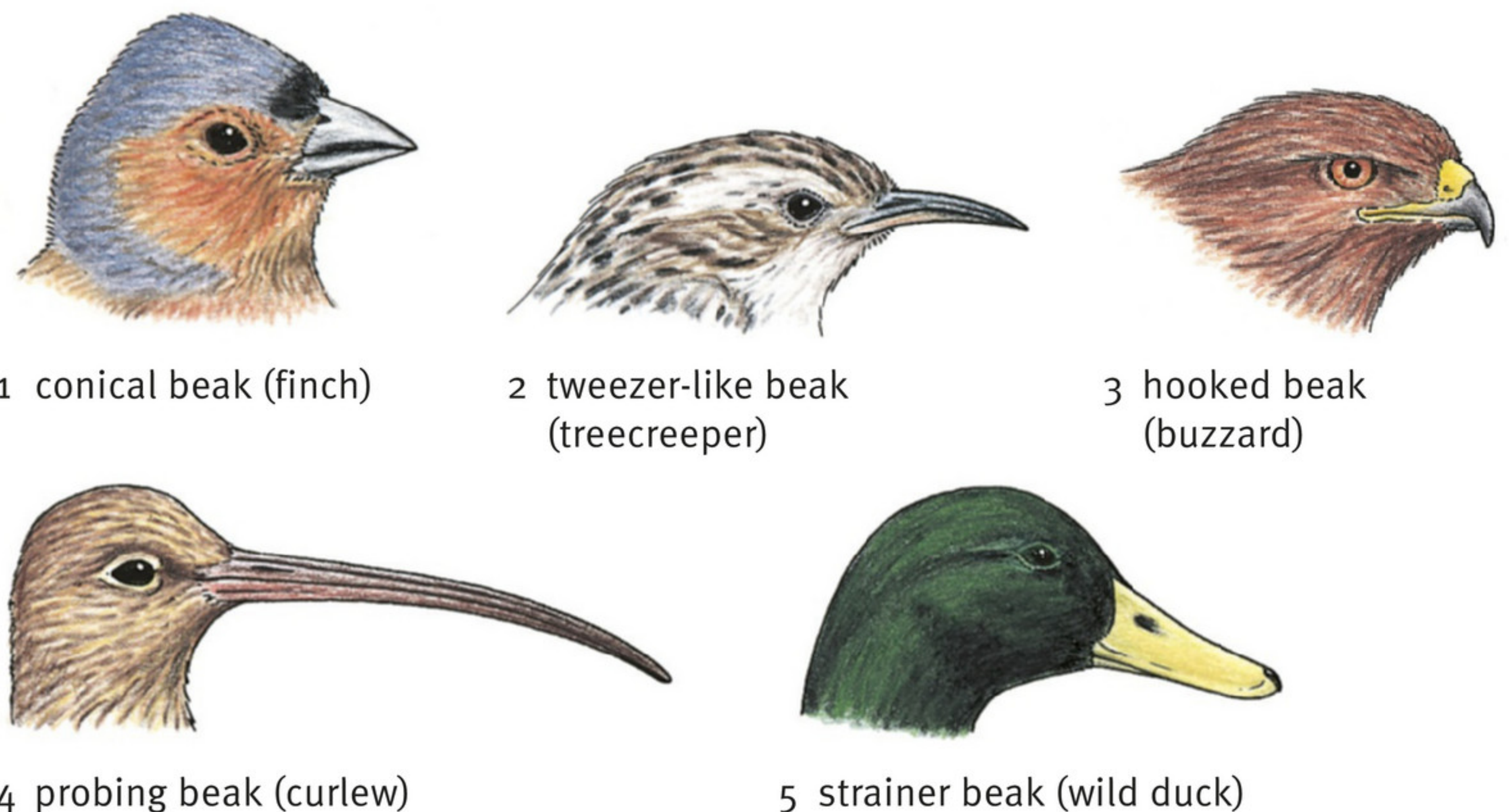
5 a curlew has legs for standing in shallow water

BIRDS' BEAKS

Several birds' heads with different types of beaks are drawn in figure 34. The beaks are adapted to the choice of diet. Some songbirds have conical beaks, others have a beaks shaped like tweezers. The **conical beak** is good for eating seeds. Because it is short, the bird can exert a lot of force with it. The **tweezer-like beak** is a pointed beak that the bird can use for catching insects (probing into cracks in tree bark, for instance). Birds of prey have a sharply **hooked beak**. It is adapted for ripping its prey apart. Birds that eat animals in the ground, such as waders, have a **probing beak**. This beak is suitable for digging deep in wet soil. Water birds may have a **strainer beak**. They take water into their beaks and push it out through the 'filter'. They can then swallow the food that remains behind.

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► Fig. 34 Birds' heads with types of beaks.



1 conical beak (finch)

2 tweezer-like beak (tree creeper)

3 hooked beak (buzzard)

4 probing beak (curlew)

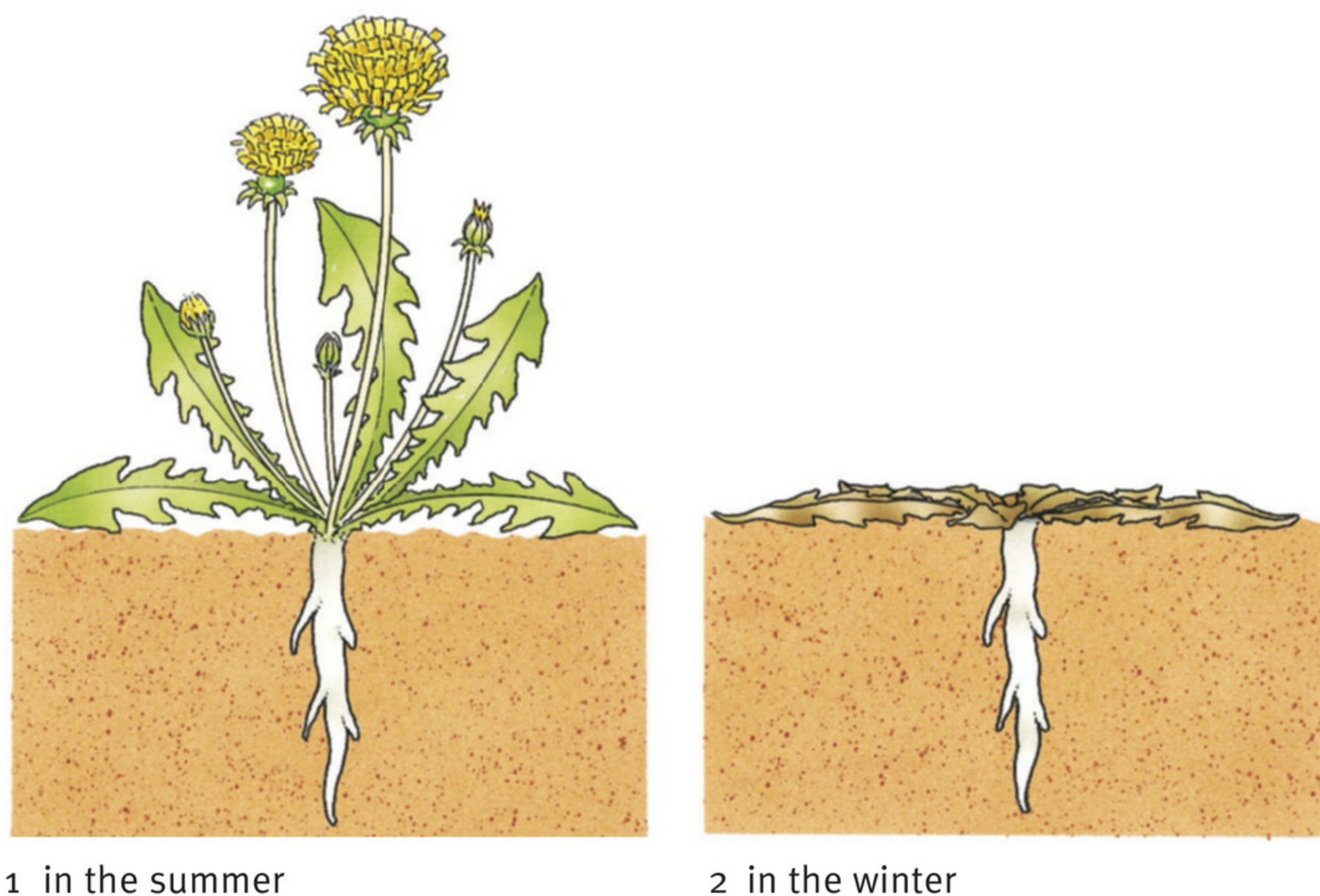
5 strainer beak (wild duck)

8 Adaptations in plants

Plants have adaptations to their biotopes too. You have already read about several of these adaptations in part 1. You learned that the parts of a dandelion that are above ground die off in the winter. The root, where reserves of food are stored, survives the winter (see figure 35).

Flowers have adaptations that increase the chance of pollination (see figure 36). Fruits and seeds can have adaptations that make dispersal (by the wind, by animals or by the plant itself) possible.

► Fig. 35 A dandelion.



▼ Fig. 36

A flower that smells of bees

The orchid *Dendrobium sinense* has a special relationship with hornets (a type of wasp). In reality, the orchid has nothing to offer the hornet. The hornet hunts bees, which in turn eat the nectar from roses, for example. The orchid spreads the scent of these bees, attracting the hornet. It does not land neatly on the petals, but plunges into the red central part of the flower. The structure of the orchid is adapted to the size and behaviour of the hornet. The opening is just big enough for the wasp, so it flies into the stamen and stigma of the flower. The wasp falls for the same deception multiple times, thus pollinating the flowers.

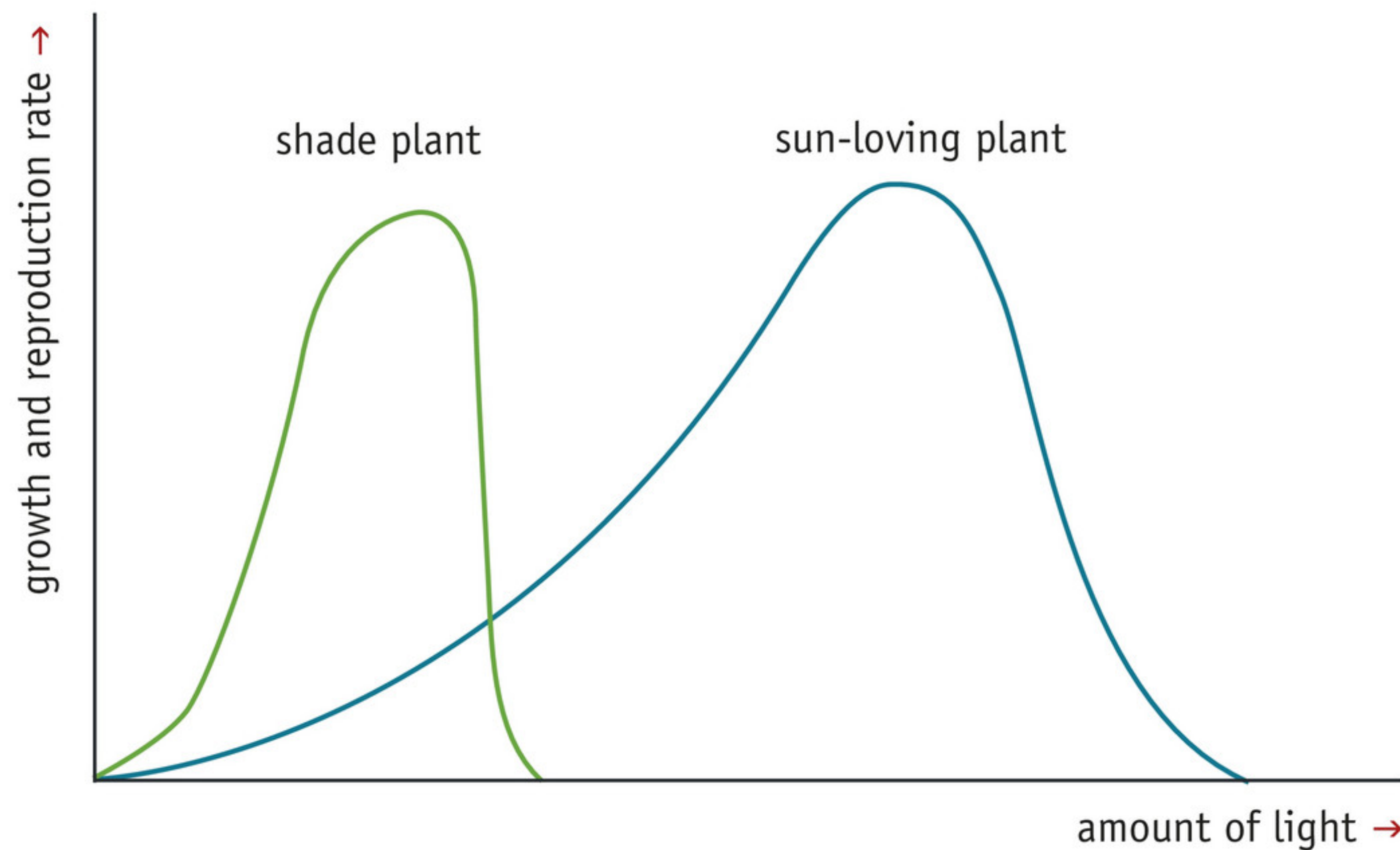


LIGHT

Plants need light for photosynthesis. The need for light is not the same in every plant (see figure 37). **Sun-loving plants** grow the best in full sunlight. They can mainly be found in areas with little to no shade, such as open fields or deserts. Sun-loving plants often have small, thick leaves. **Shade plants** grow best where there is not much light. They can be found in shady areas, for example as ground cover in deciduous forests. Shade plants often have large, thin, dark green leaves. The differences between sun-loving plants and shade plants can also be seen in houseplants (see figure 38).

In a lot of plants the amount of light influences the formation of flowers. Shade plants from the ground cover in deciduous woods often flower early in the spring. That is when they can get the most light. These plants are known as **spring-blooming plants**.

▼ Fig. 37



▼ Fig. 38 Sun-loving plants and shade plants.

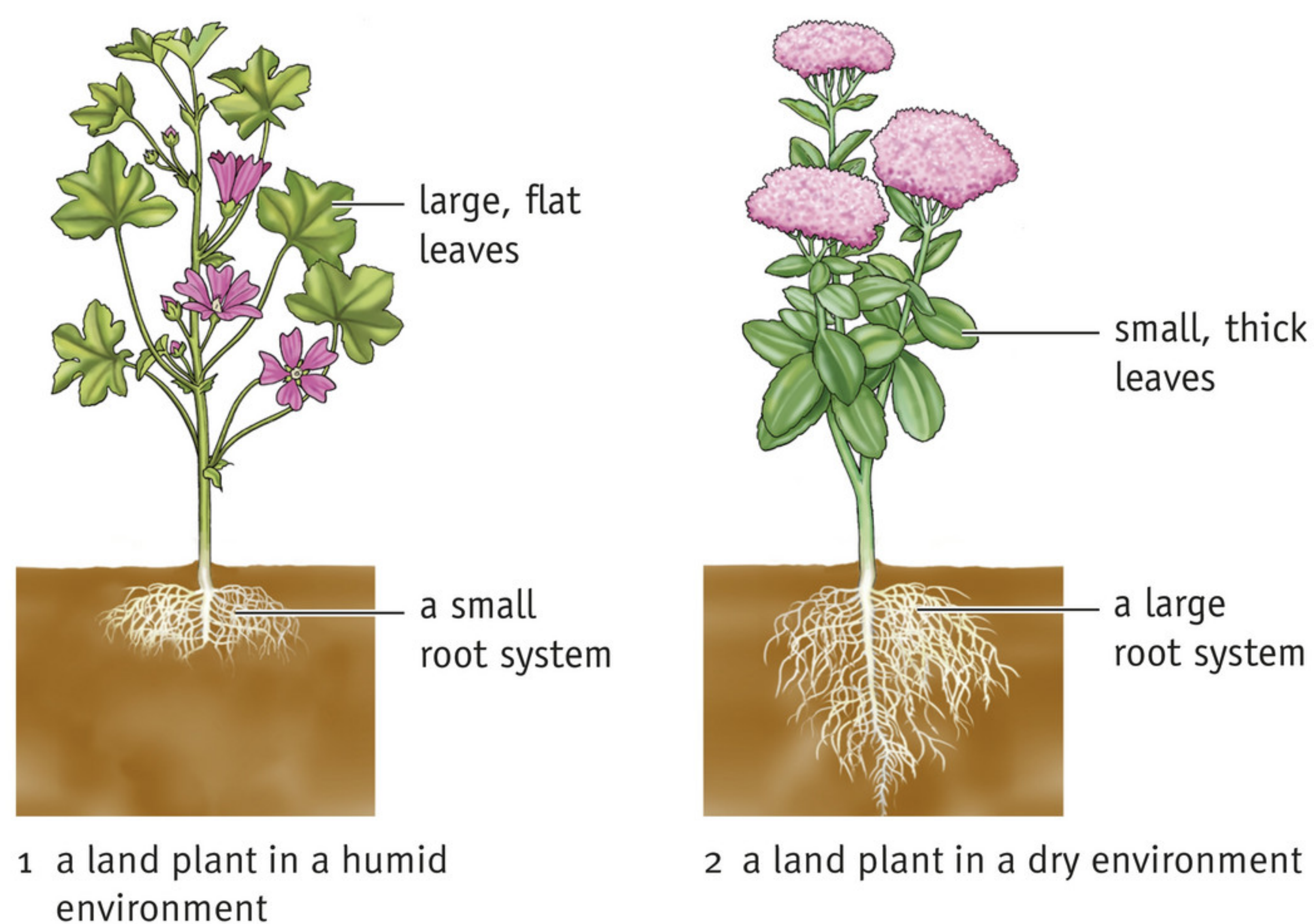


DROUGHT

Plants can also have adaptations to prevent dehydration. A number of land plants with these adaptations are drawn in figure 39. For plants that live in water, there is no danger of dehydration.

Like aquatic animals, water plants are 'supported' by the water. They therefore do not have many tough parts. Light can not reach deep down into water, especially when the water is muddy or polluted. Because plants need light for photosynthesis, most plants only grow in the upper layers of the water.

► **Fig. 39** Adaptations in plants to prevent dehydration.

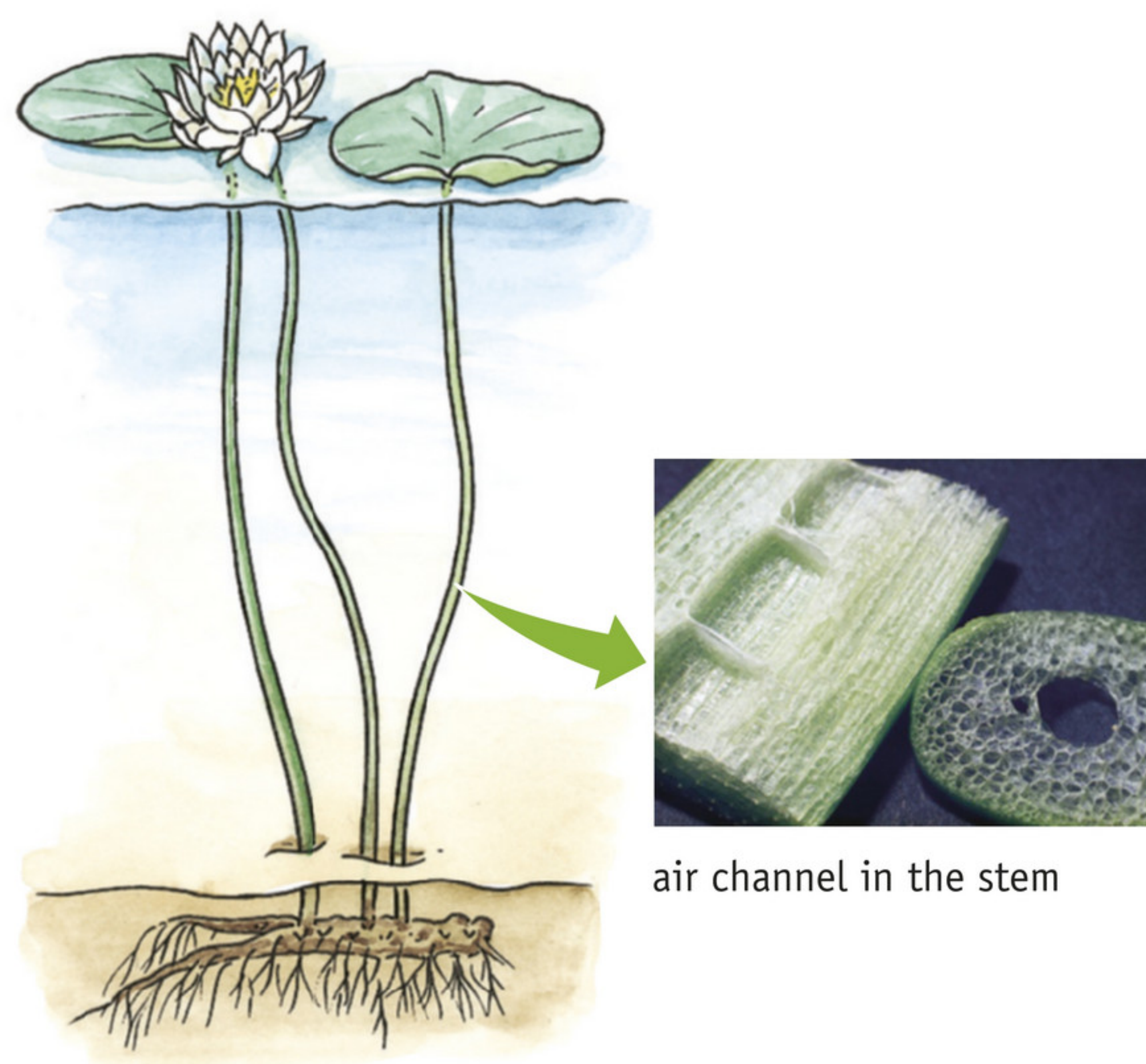


Water lilies can only grow in water that is no deeper than four metres (see figure 40). Water lilies are attached to the soil by their roots. Their leaves float on the water. The stems are soft and have air channels. The roots get oxygen from the leaves through these air channels. The flowers of water lilies protrude above the water.

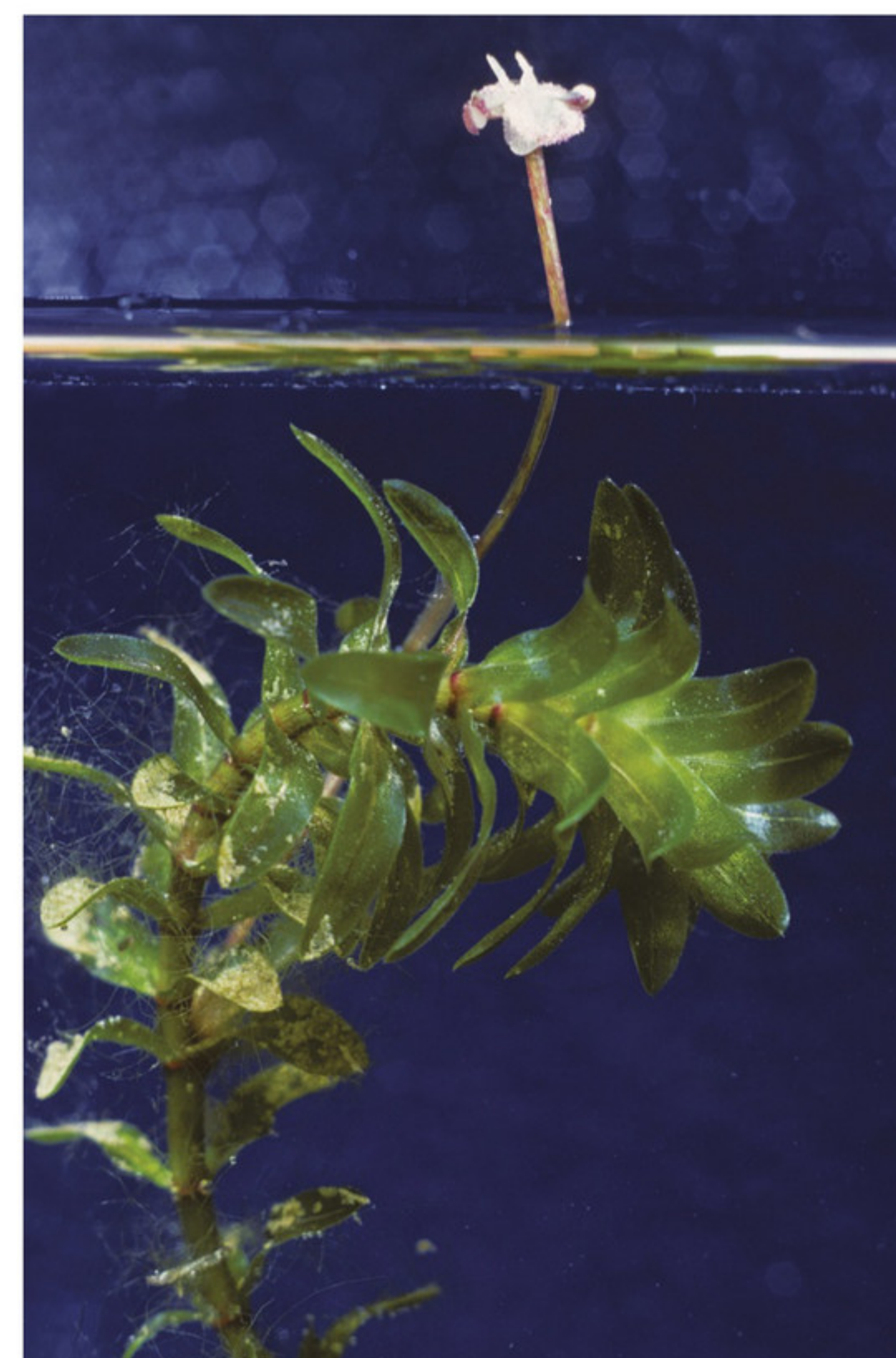
Waterweed has a soft stem and very thin leaves (see figure 41). All of its leaves are under water. Only the flowers of waterweed protrude above the water.

WB EXERCISES 27 TO 29, PAGE 68

▼ **Fig. 40** Water lily.



▼ **Fig. 41** Waterweed.



9 Autotrophs and heterotrophs

In part 1, you learned that plants can photosynthesise because they have chlorophyll. In photosynthesis, an energy-rich compound (glucose) is made from carbon dioxide and water. You have also learned that glucose serves as raw material for making all the substances that plants are made of. To make these substances, plants absorb minerals from the soil. Plants do not feed on other organisms. They take the substances they need from non-living nature. If an organism does not need other organisms as food, we call that organism an **autotroph** (*autos* = self, *trophein* = feeding).

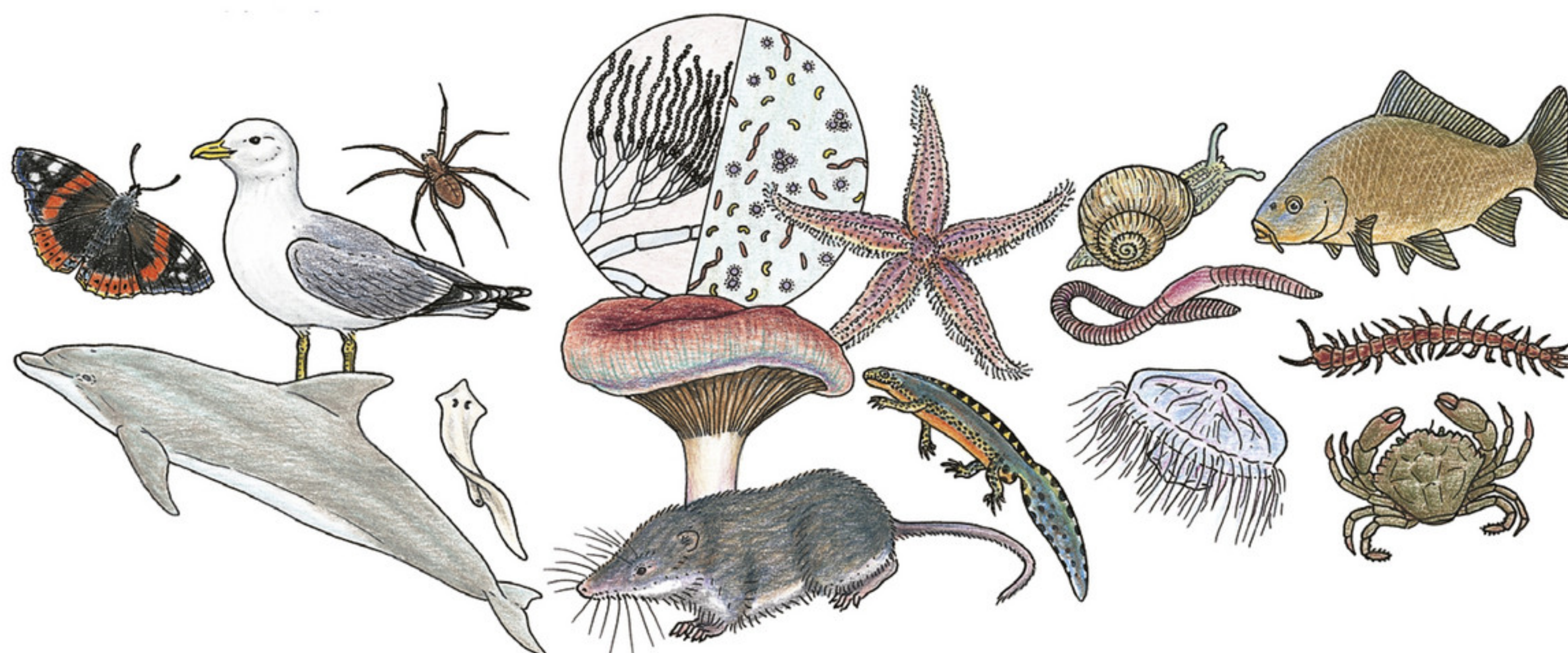
▼ Fig. 42 Autotrophic organisms.



Organisms with no chlorophyll cannot stay alive with only substances from non-living nature. Substances from non-living nature do not contain a lot of energy. Organisms with no chlorophyll cannot create energy-rich compounds from these energy-poor compounds. They have to take in energy-rich substances with their food. That is why they must feed on other organisms. Animals, fungi and most bacteria do not have chlorophyll. These organisms feed on other organisms. We call such an organism a **heterotroph** (*heteros* = other, *trophein* = feeding).

WB EXERCISES 30 AND 31, PAGE 71

► Fig. 43 Heterotrophic organisms.



10 The energy flow in an ecosystem

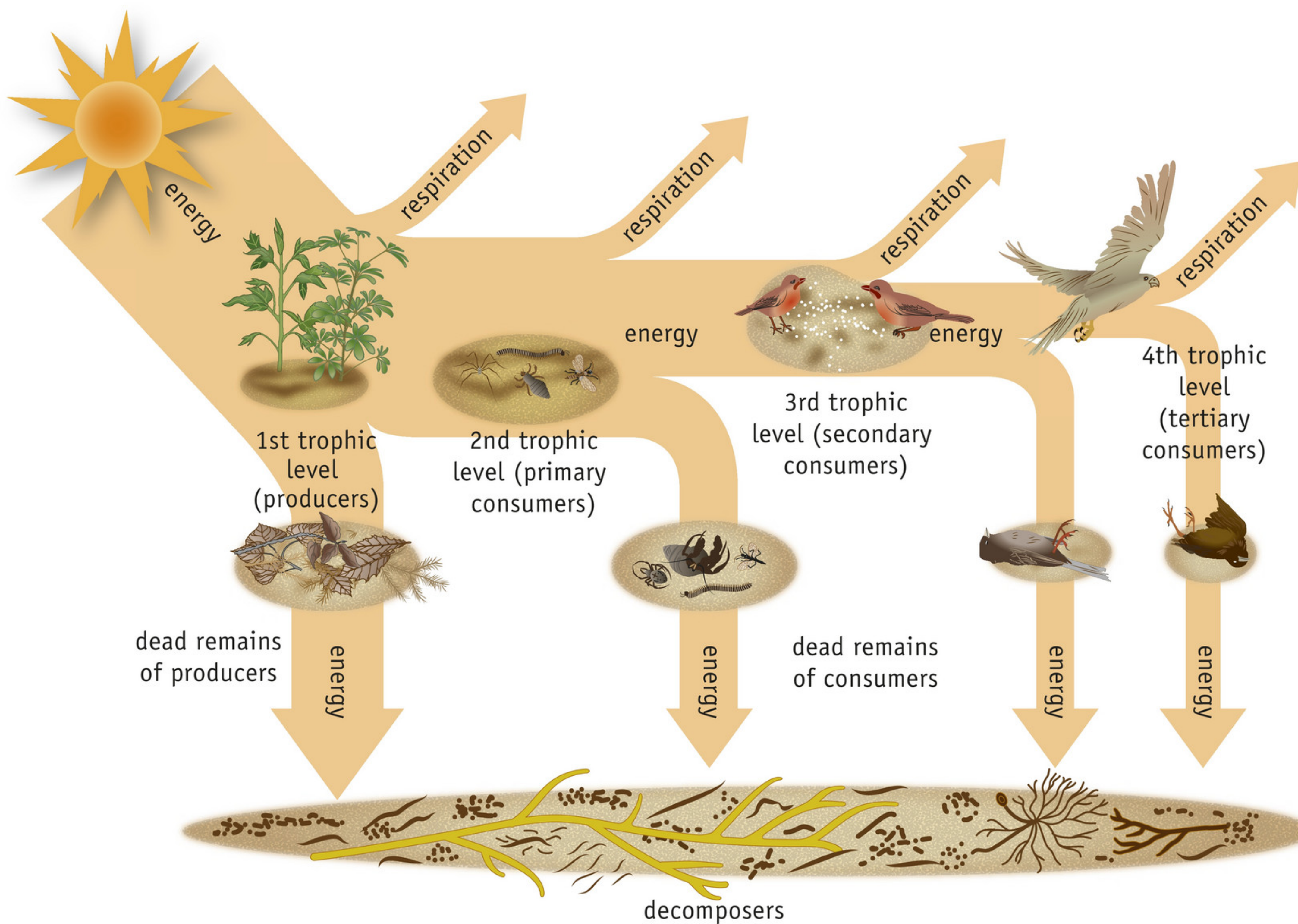
The place of an organism in a food chain is called the **trophic level**. Producers are the first trophic level, primary consumers the second trophic level, secondary consumers the third trophic level, and so forth. The biomass in each trophic level decreases. This is because the energy in the food gets used in several different ways.

ENERGY FLOW

In ecosystems, the energy of one trophic level is passed up to the next trophic level. This is called an **energy flow** (see figure 44). Plants store the energy from sunlight in glucose through photosynthesis. This energy gets released when glucose is burned or used. That is why we call glucose an **energy-rich compound**.

In plants, glucose is used for making other substances. Because the energy from the glucose has now been transferred to these other substances, they are also energy-rich compounds. Examples of such substances are DNA, proteins, carbohydrates and fats. These are the building blocks that organisms are made of.

▼ Fig. 44 Energy flow in an ecosystem.



Energy is needed to produce these building blocks, which is why the plant uses part of the glucose in respiration. Other processes, such as the transportation of substances, also need energy. As a result of respiration part of the energy is not available for the next trophic level, but is lost as heat instead.

Part of the biomass of producers gets eaten by consumers. This is how the energy of these producers gets passed up to the next trophic level. Consumers use part of the energy-rich compounds for growth, increasing their biomass. The remainder of the energy-rich compounds gets used in respiration. This releases energy so that they can move, for example.

Each link in a food chain produces waste from the organisms in it. Some individuals also die without getting eaten. The energy-rich compounds of these dead remains disappear from the food chain. The energy from these energy-rich compounds is used by decomposers. Eventually, all the energy-rich compounds do get used. Water and carbon dioxide become available again for plants, which can capture the energy from sunlight again.

EATING INSECTS

Most animals in livestock farming use only a small part of the energy-rich compounds they absorb as building blocks. They use most of it as fuel. For each kilogram of meat an animal puts on, it needs to have eaten many kilograms of food. But only that one kilogram of meat can be passed on to the next link in the food chain.

The ratio of the amounts of energy absorbed and passed on is a lot more favourable in insects. That is why the advice to eat insects is becoming more and more common. Eating insects could be a solution for the ever-greater demand for food from the growing world population. In non-Western countries, eating insects is perfectly normal (see figure 45).

WB EXERCISE 32, PAGE 72

► **Fig. 45** Eating insects means less energy is lost.



Summary

OBJECTIVE 1

You have to be able to classify influences on organisms into biotic and abiotic factors.

- Biotic factors: influences from living nature.
 - e.g. members of the same species, predators, pathogens.
- Abiotic factors: influences from non-living aspects of nature.
 - e.g. temperature, light, wind, amount of oxygen in the air, rainfall, soil condition.

OBJECTIVE 2

You must be able to describe the different levels of ecology.

- Individual: one single organism.
- Population: a group of individuals of the same species that live together in an area and reproduce with one another.
- Community: all the populations that live in an ecosystem.
- Ecosystem: a certain area in which the biotic and abiotic factors form a unit.
 - Biotope: the sum of the abiotic factors in an ecosystem.

OBJECTIVE 3

You can name the different feeding relationships in an ecosystem.

- Food chain: a series of organisms, whereby each organism is the food source for the next organism.
 - All food chains start with a plant.
- Food web: all the feeding relationships in an ecosystem.
 - In a food web, the food chains are interrelated and form a network.

OBJECTIVE 4

You can describe the nutrient cycle in an ecosystem and name different types of organisms within it.

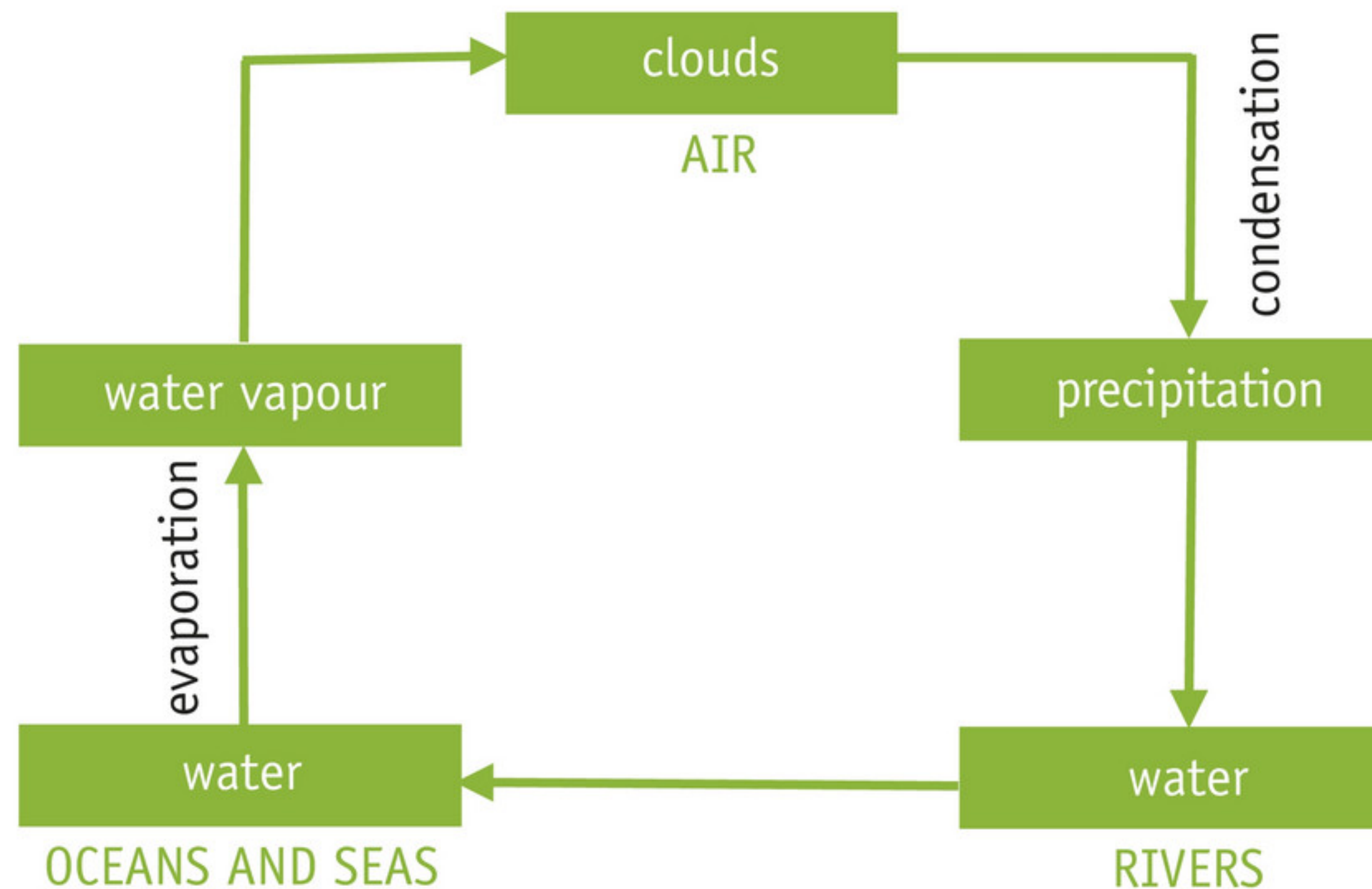
- Producers: provide the food for all other organisms.
 - Plants are producers. Photosynthesis takes place in the green parts of plants.
- Consumers: eat the materials made by plants.
 - Primary consumers are eaten by secondary consumers that are eaten by tertiary consumers, etc.
 - Herbivores, carnivores, omnivores and scavengers are all consumers.
 - Animals are consumers.
- Decomposers: break down dead organisms and their wastes.
 - This releases minerals that are reused by the producers.
 - Bacteria and fungi are decomposers.

OBJECTIVE 5

You can describe the water cycle and the carbon cycle.

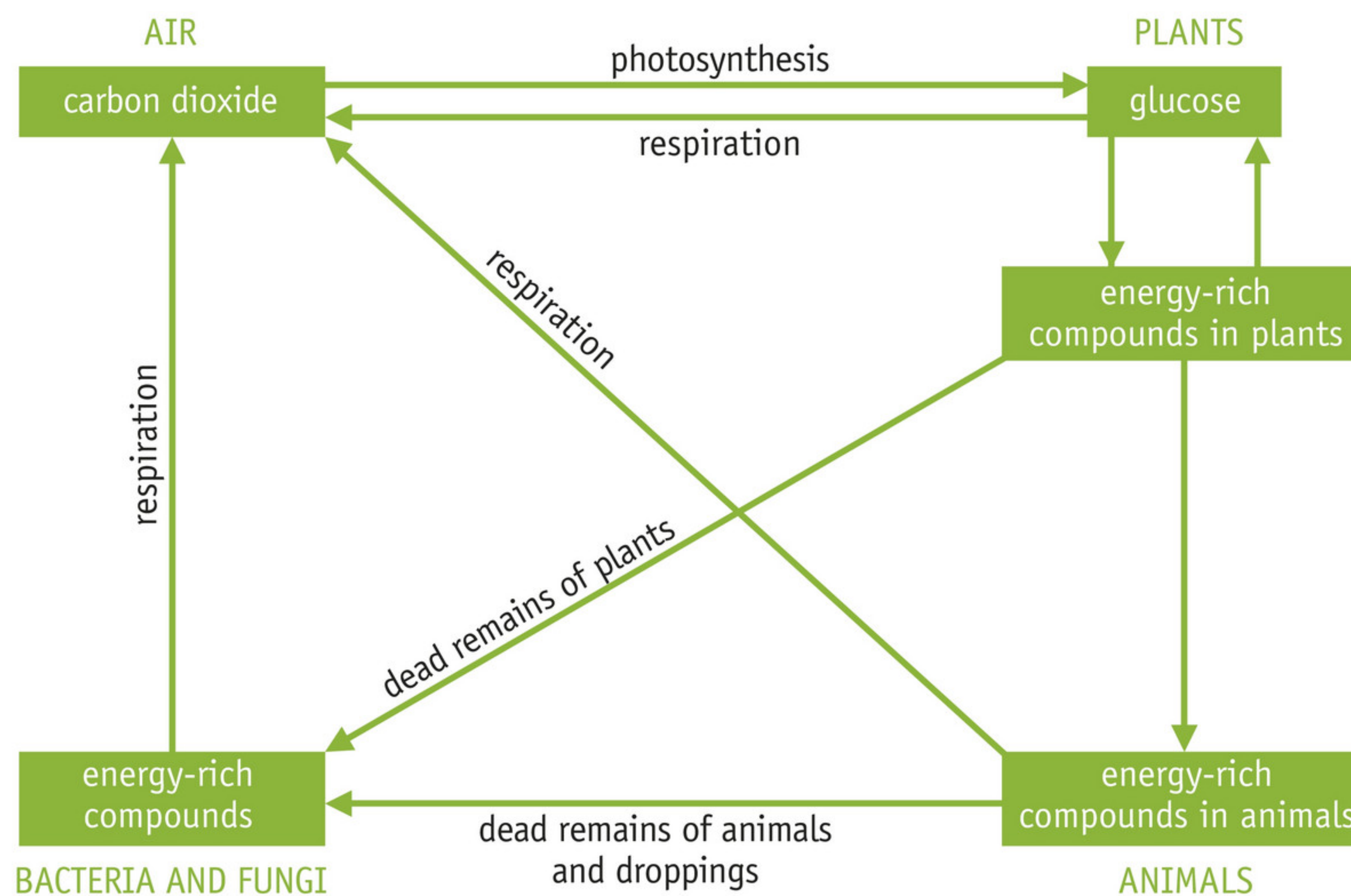
- The water cycle.

▼ Fig. 46



- The carbon cycle.

▼ Fig. 47

**OBJECTIVE 6**

You can describe the information shown in pyramids of numbers and pyramids of biomass.

- Pyramid of numbers: shows the number of organisms in each link of a food chain.
 - The number of individuals in each subsequent link of a food chain usually decreases.
 - Sometimes this is not the case. The pyramid of numbers then loses its pyramid shape.
- Pyramid of biomass: shows the amount of biomass contained in each level of a food chain.
 - Biomass: the total weight of all energy-rich compounds.
 - The biomass at each subsequent level of a food chain decreases.
 - The pyramid of biomass always has a pyramid shape.

OBJECTIVE 7

You can describe the influence of biotic and abiotic factors on the size of a population.

- Optimum conditions: all biotic and abiotic factors are at their most favourable.
 - The rates of growth and reproduction of a population are at their maximum.
- Biological equilibrium: a situation in which the size of each population in the ecosystem fluctuates around a certain value.

- The size of each population depends on biotic and abiotic factors.
 - Organisms have adaptations to the environment in which they live.
 - The growth and reproduction rate of the population can be shown in a tolerance curve for each abiotic factor.

OBJECTIVE 8

You can describe what ecological succession is and you can distinguish between a pioneer community and a climax community.

- Succession: the process by which the species of plants and animals in a given area change gradually over time, allowing one ecosystem to transform gradually into another.
- Humus: the topsoil.
 - Humus consists of dead remains and decomposers.
- Pioneer community: the first ecosystem that forms on barren terrain.
 - The abiotic factors vary a great deal.
 - The soil is low in humus.
 - The ecosystem does not contain many species.
 - There are lots of individuals of each species.
 - The food web is simple.

- Climax community: the final stage of succession (e.g. a deciduous forest).
 - The abiotic factors are more or less constant.
 - The soil is rich in humus.
 - The ecosystem is rich in species.
 - The food web is complex.

OBJECTIVE 9

You can describe the ways in which animals are adapted to their biotope.

- Adaptations in aquatic animals reduce water resistance as much as possible.
 - The body is streamlined.
 - In fish the scales are covered in a layer of slime.
- Adaptations in terrestrial animals let them bear their own weight.
 - Strong legs.
 - A sturdy skeleton.
- Adaptations in terrestrial mammals to the ground conditions.
 - Plantigrades: walk on the entire sole of the foot (e.g. apes, bears). This means that their feet do not sink easily into soft ground.
 - Digitigrades: walk on their toes (e.g. dogs, cats).
 - Unguligrades (hoofed animals): walk on the tips of their toes (e.g. horses, deer). This lets them reduce resistance from the ground while walking. Unguligrades can only walk well on hard surfaces.
- Adaptations in birds' legs.
 - Many birds have three toes that point forwards and one that points backwards (e.g. songbirds). This means they can perch on branches.
 - Birds of prey have sharp claws.
 - Flightless birds do not have a toe that points backwards.
 - Water birds have webbed feet (e.g. ducks).
 - Waders have long legs.
- Adaptations in birds' beaks.
 - Conical beak: in birds that eat seeds.
 - Tweezer-like beak: in birds that eat insects.
 - Hooked beak: in birds of prey.
 - Probing beak: in birds that eat animals in the ground (e.g. waders).
 - Strainer beak: in animals that filter small plants and animals out of the water (e.g. ducks).

OBJECTIVE 10

You can describe adaptations to the biotope.

- Adaptations to the amount of light.
 - Sun-loving plants: often have small, thick leaves.
 - Shade plants: often have large, thin, dark green leaves.
 - Spring-blooming plants: there is most light on the forest floor in the spring.
- Adaptations in plants that grow in damp conditions.
 - Large flat, leaves.
 - A poorly developed root system.
- Adaptations in plants that grow in dry conditions.
 - Small, thick leaves (or in cactuses: spines or thick hairs).
 - Sometimes water storage in the stems (e.g. in cactuses).
 - A well-developed root system.
- Adaptations in water plants.
 - The stems are soft.
 - The stems can contain air channels (e.g. in water lilies).

EXTRA OBJECTIVE 11

You must be able to list the differences between autotrophs and heterotrophs.

- Autotrophs:
 - have chlorophyll;
 - carry out photosynthesis in sunlight;
 - can make energy-rich compounds from energy-poor compounds;
 - do not require other organisms for their food;
 - only take up energy-poor compounds from the environment.
- Heterotrophs:
 - do not have chlorophyll;
 - do not carry out photosynthesis;
 - cannot make energy-rich compounds from energy-poor compounds;
 - require other organisms for their food;
 - take up energy-rich and energy-poor compounds from the environment.

EXTRA OBJECTIVE 12

You can describe the energy flow in an ecosystem.

- The energy flow in an ecosystem: energy is lost from the food chain in each link of the chain.
 - Some individuals die without getting eaten by individuals from the next link.
 - Of the individuals that do get eaten, not all of the organism is digested. This remainder ends up in the droppings.
 - Of the substances that do get digested, part gets used as fuel in respiration. Respiration releases energy mainly in the form of movement and heat.
 - The remaining part can be used as building blocks. This part can then serve as food for the next link in the food chain.

SKILLS AND COMPETENCIES**BASICS**

- You have learned how to draw pyramids of numbers and pyramids of biomass.
- You have learned how to calculate the density of a population.
- You have practised getting information from articles.
- You have practised reading graphs.

EXTRA

- You have practised reading graphs.

The diagnostic test does not include any questions about these competencies/skills.

You have met an ecologist and a game butcher in this unit. You have also seen applications in science and daily practice that use the material from this unit.

Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the score sheet in your workbook.

OBJECTIVE 1

Figure 48 is an article about beech trees. This article lists several biotic and abiotic factors.

- 1 List three biotic factors that are mentioned in the article.
- 2 List three abiotic factors that are mentioned in the article.

▼ Fig. 48

Beech

Lots of beech trees grow naturally in the Netherlands. Beeches are mostly wind-pollinated. In the spring you can see both male and female catkins. After fertilisation, the female flowers grow into fruits with spines, in which beech nuts develop. When the beech nuts are ripe, the fruits open up and the beech nuts fall to the ground. The beech nuts get dispersed by animals such as squirrels, which stockpile them as winter food. Beeches grow on moist, permeable soil. The tree lives together with a fungus that plays a role in the absorption of water.



OBJECTIVE 2

Write down which level of ecology the following descriptions are about.

- 1 A group of individuals of the same species in a certain area that reproduce together.
- 2 A forest.
- 3 A deer in a wood (see figure 49).
- 4 The wood anemones in a wood.
- 5 All the organisms in an ecosystem.

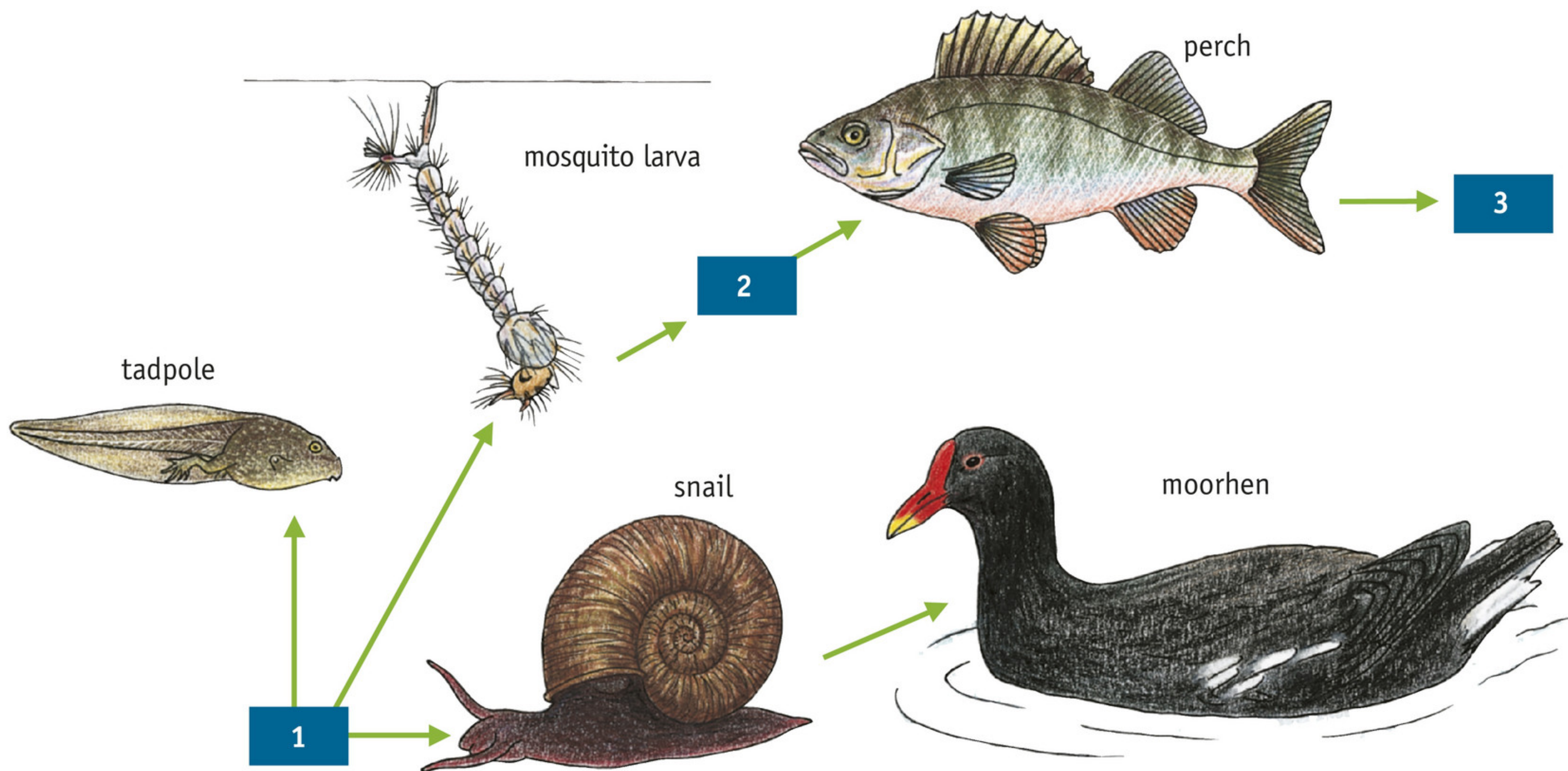
▼ Fig. 49



OBJECTIVE 3

- 1 Your workbook contains a diagram of a food web. Fill in the following organisms in the correct places in this diagram: *clover* – *field mouse* – *fox* – *owl* – *rabbit* – *wheat plant*.
- 2 Figure 50 shows a schematic drawing of several feeding relationships in a freshwater community. Three links (labelled 1, 2 and 3) have not been filled in. *Plant plankton*, a *pike* (a predatory fish) and a *water beetle* (a predatory water insect) are missing from the diagram. Fill in the correct organisms at 1, 2 and 3.

▼ Fig. 50

**OBJECTIVE 4**

Answer the following multiple choice questions.

- 1 Depending on their choice of diet, an animal may be classified as an omnivore, herbivore or carnivore. Which of these groups of animals is/are consumers in the nutrient cycle?
 - A Only the herbivores.
 - B Only the omnivores and the carnivores.
 - C The omnivores, the herbivores and the carnivores.
- 2 Read the text in figure 51. Are squirrels omnivores, herbivores or carnivores?
 - A Omnivores.
 - B Herbivores.
 - C Carnivores.
- 3 Dry rot is a fungus. Dry rot in houses can damage wooden floor joists, eventually leading to the residents falling through the floor. Is the dry rot fungus a consumer, producer or decomposer?
 - A Consumer.
 - B Producer.
 - C Decomposer.

▼ Fig. 51

Fewer squirrels

Squirrels in the Netherlands have been affected by a lack of acorns and beech nuts. In the period from 2008 to 2011 there was already a shortage of these woodland products. That shortage was followed in 2012 by a long winter with a lot of snow. In addition to acorns and other seeds, squirrels also eat insects and sometimes even young birds.

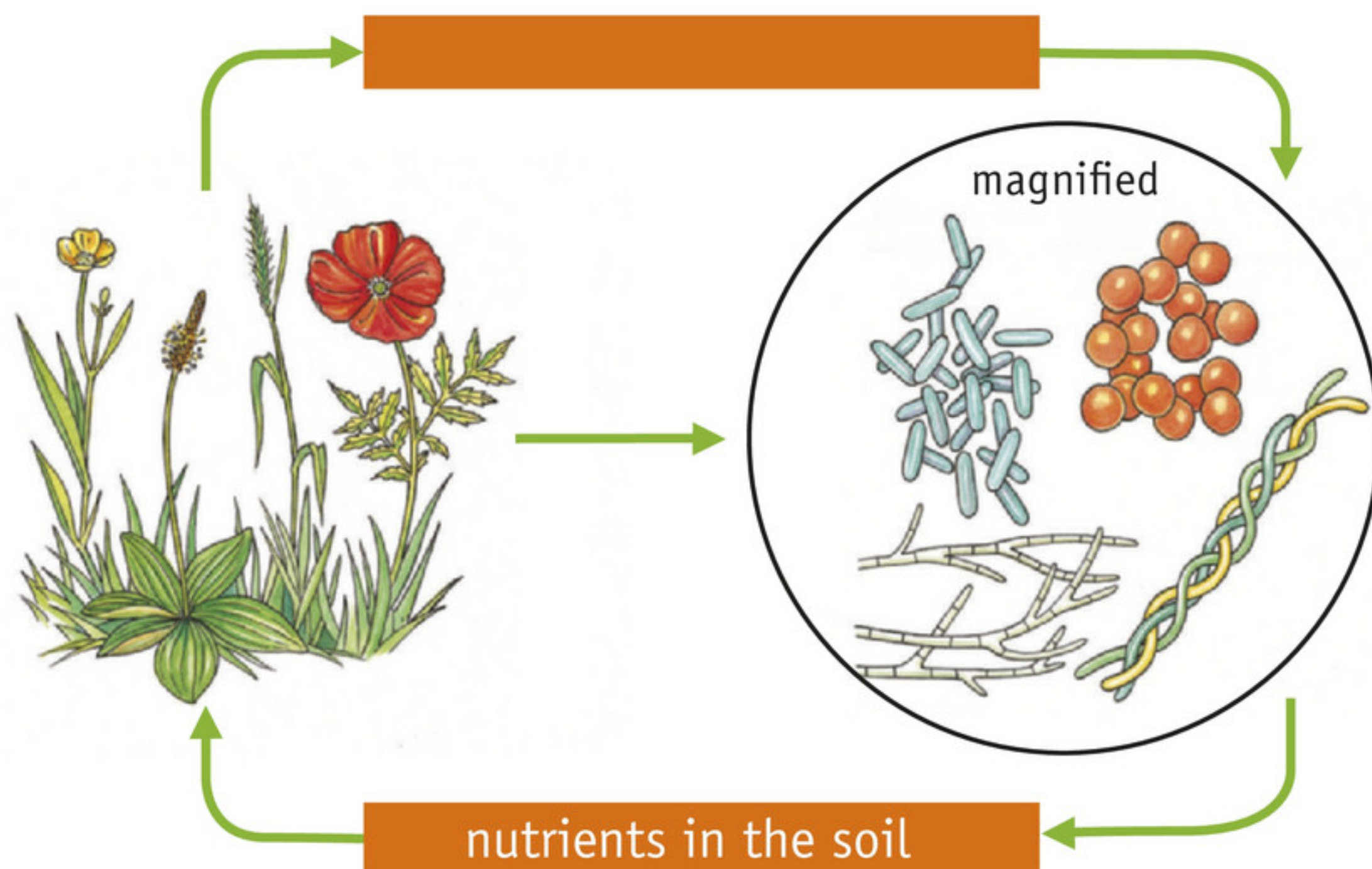


- 4 The drawing in figure 52 shows a diagram of a cycle of nutrients.

To complete the cycle, what should the empty box say?

- A Consumers.
- B Producers.
- C Decomposers.

▼ Fig. 52



- 5 In which group of organisms can the organisms make glucose from water and carbon dioxide?

- A Consumers.
- B Producers.
- C Decomposers.

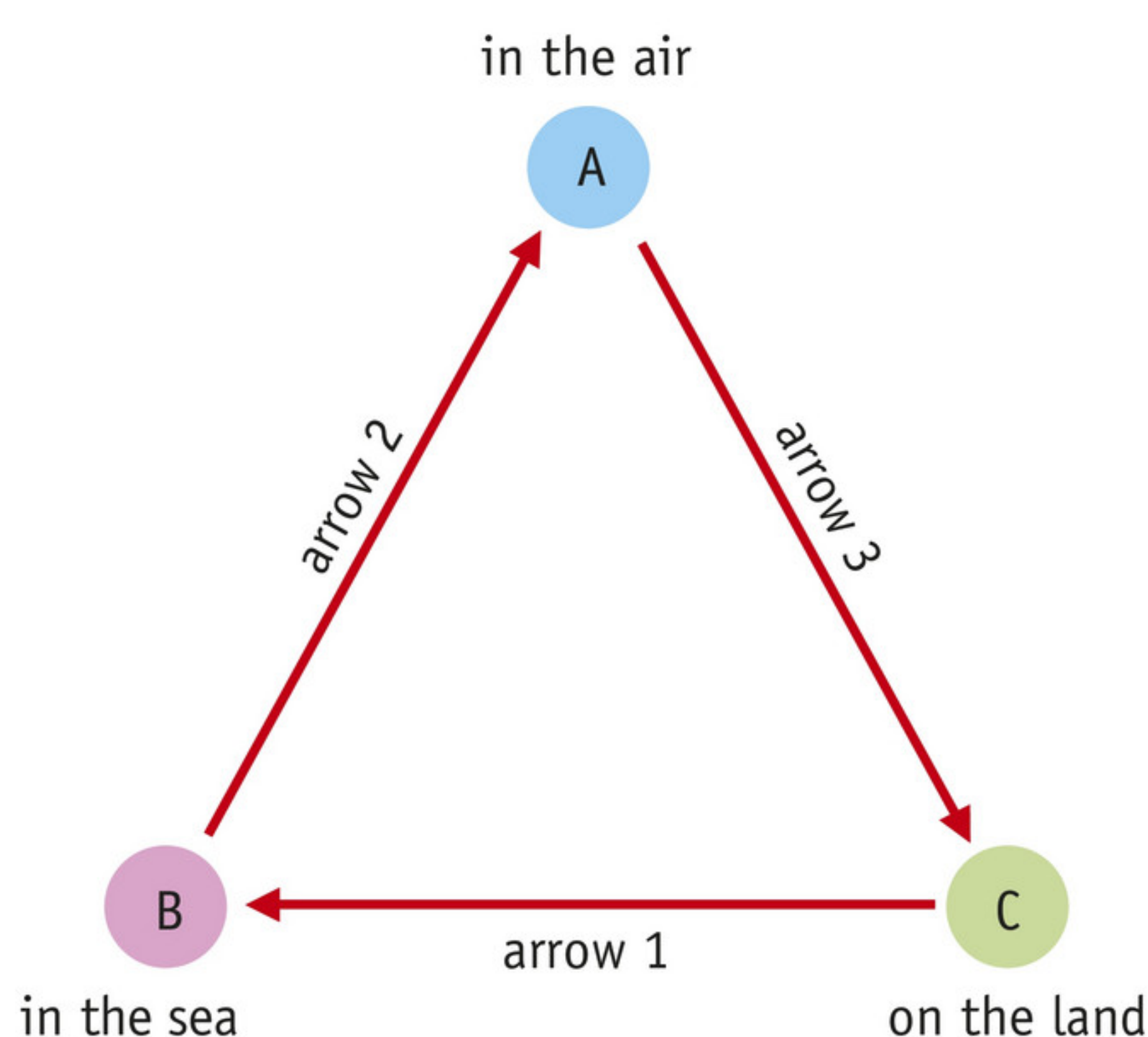
OBJECTIVE 5

Answer the following questions.

The drawing in figure 53 is a diagram of the water cycle. Three arrows are numbered.

- 1 Which arrow (or arrows) represents condensation?
- 2 Which arrow (or arrows) represents evaporation?
- 3 At which arrow (or arrows) can hailstones be part of the water cycle?

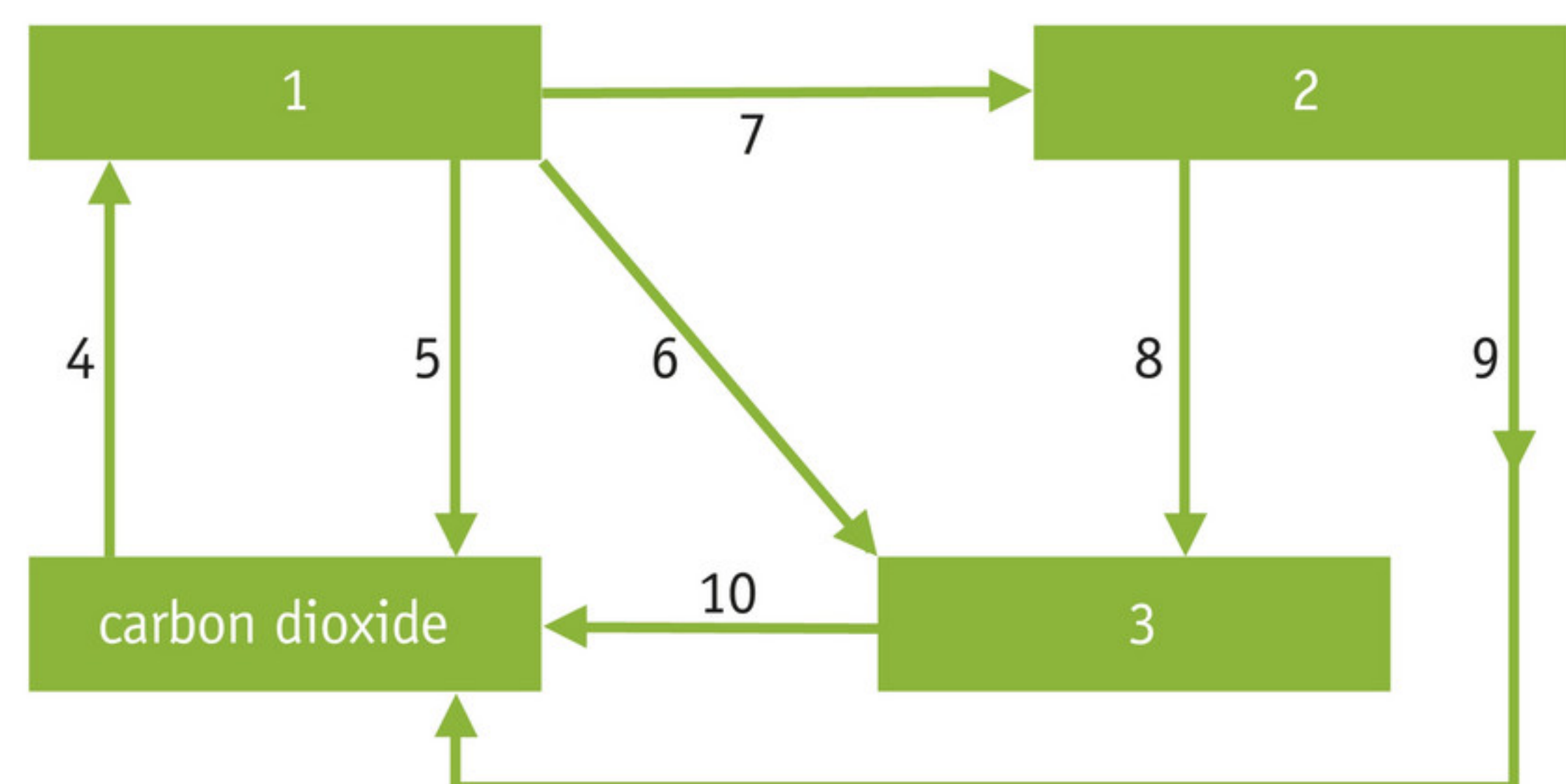
▼ Fig. 53



The drawing in figure 54 shows a diagram of the carbon cycle. Three boxes and seven arrows are numbered.

- 4 Which box represents the energy-rich compounds in producers?
- 5 Which box represents the energy-rich compounds in decomposers?
- 6 Which box represents the energy-rich compounds in animals?
- 7 Which arrow (or arrows) represent photosynthesis?
- 8 Which arrow (or arrows) represent respiration?
- 9 Which arrow (or arrows) represent the dead remains of organisms?

▼ Fig. 54



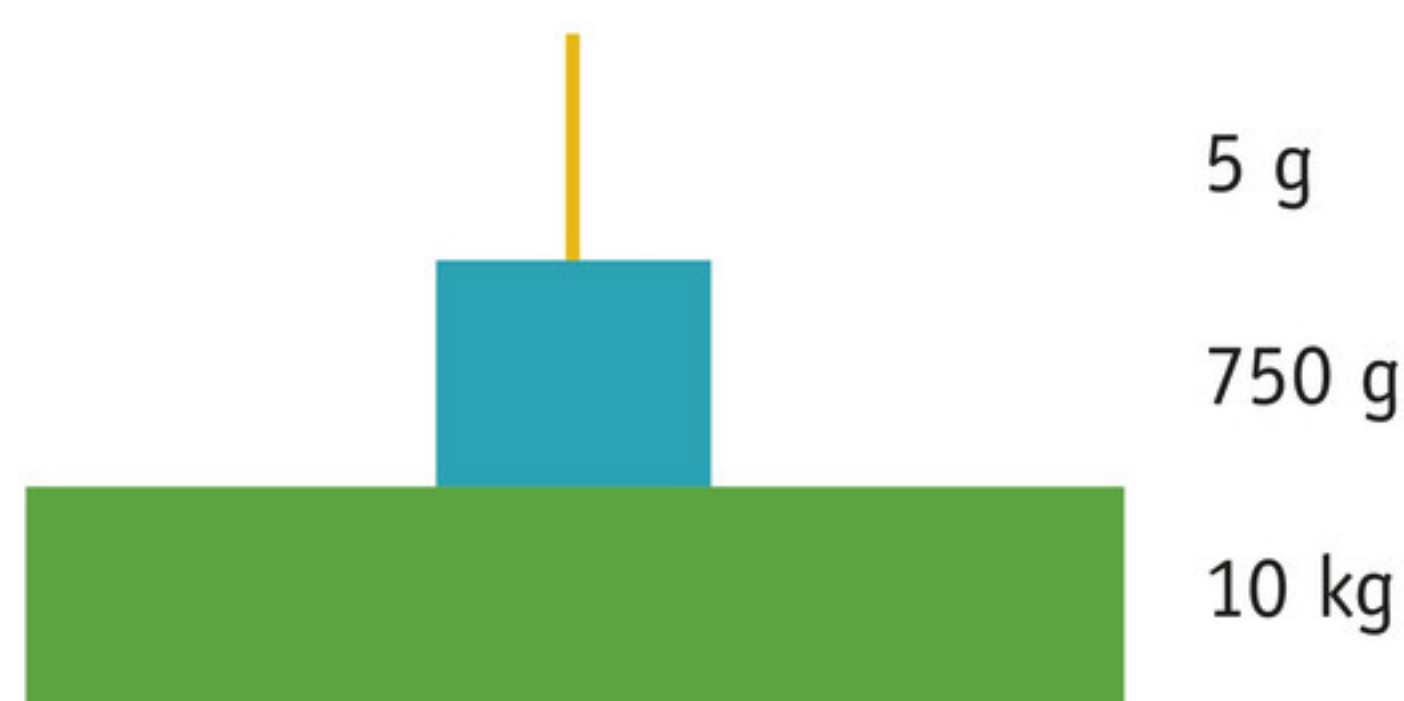
OBJECTIVE 6

Answer the following multiple choice questions.

- 1 Does a pyramid of numbers always have a pyramid shape? Why?
 - A Yes, because a pyramid of numbers always shows the links of a food chain in the correct order.
 - B Yes, because the number of individuals in each subsequent link of a food chain always decreases.
 - C No, because a pyramid of numbers may sometimes show the links of a food chain in a different order.
 - D No, because the number of individuals in a later link in a food chain can be larger.

- 2 Figure 55 is a drawing of a pyramid of biomass of the food chain of algae → mosquitoes → frogs. Which of the following statements is true?
- A From 5 g of biomass in algae, 750 g of biomass in mosquitoes is formed.
 - B From 5 g of biomass in algae, 10 kg of biomass in frogs is eventually formed.
 - C From 750 g of biomass in algae, 5 g of biomass in frogs is formed.
 - D From 750 g of biomass in mosquitoes, 5 g of biomass in frogs is formed.

▼ Fig. 55



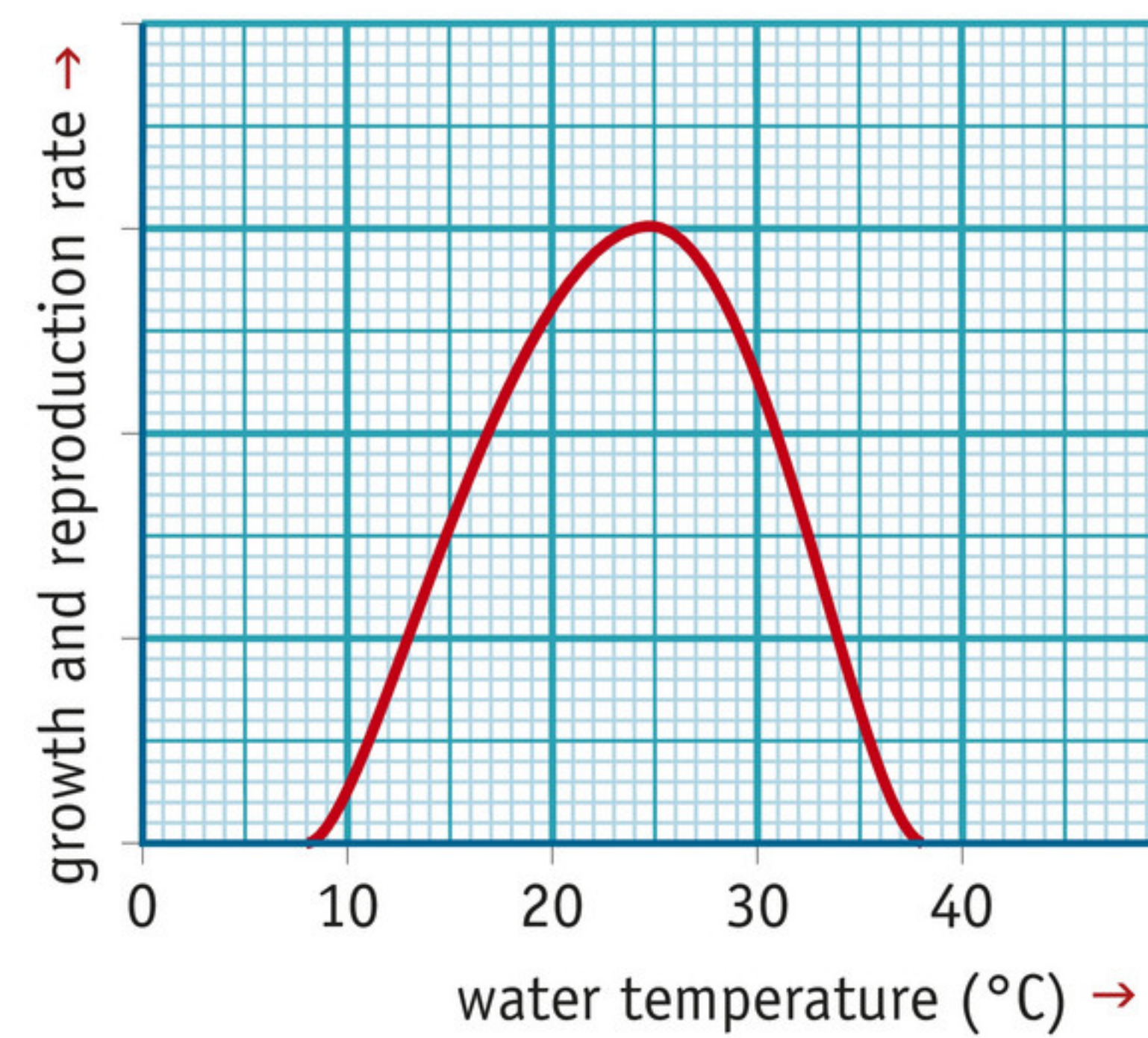
- 3 The biomass of each level of a food chain was calculated for a food chain with four levels. The biomasses are: 1 kg, 20 kg, 400 kg and 40,000 kg. What is the total amount of biomass of all the consumers in this food chain?
- A 20 kg.
 - B 400 kg.
 - C 421 kg.
 - D 40,000 kg.

OBJECTIVE 7

Answer the following questions.

- 1 The graph in figure 56 shows the relationship between the temperature in the environment and the growth and reproduction rate of the channel catfish (see figure 57). At what temperature are the conditions for growth and reproduction of the channel catfish at their best? What is the term for this temperature?
- | | |
|---|---------------------------------------|
| <p><i>The best temperature for growth and reproduction is</i></p> | <p><i>This temperature is the</i></p> |
| A 25°C. | maximum temperature. |
| B 25°C. | optimum temperature. |
| C 37°C. | maximum temperature. |
| D 37°C. | optimum temperature. |

▼ Fig. 56



▼ Fig. 57 Channel catfish.



▼ Fig. 58



- 2 Figure 58 shows a grassland and several organisms that can be found there. For several summers it is very dry. As a result there is less and less grass in the area shown in figure 58.

How will this affect the number of short-eared owls in this area? And how will it affect the number of field mice?

	<i>The number of short-eared owls will</i>	<i>The number of field mice will</i>
A	increase.	increase.
B	increase.	decrease.
C	decrease.	increase.
D	decrease.	decrease.

- 3 Figure 59 is an article about polecats. Two statements made in response to this article were:
- 1 If dead wood and branches are cleared away again, the rabbit population will increase.
 - 2 The community described in the Biesbosch is in equilibrium if the number of polecats is equal to the sum total number of mice, hares and rabbits.

Which of these statements is/are true?

- A Neither of them.
 B Only 1.
 C Only 2.
 D Both 1 and 2.

▼ Fig. 59

Polecats in the Biesbosch

There have been more and more polecats in the Biesbosch in recent years. This is the result of a type of nature management in which wood and branches in a forest are no longer being cleared away. Polecats like to sit in piles of dead wood. They also use them as nesting sites. Polecats eat mice, hares and rabbits. The piles of wood take up space where grass could grow. But there is still space for the grass that mice, hares and rabbits eat.



OBJECTIVE 8

Say whether each of the following statements is true or false.

- 1 Ecological succession means that one ecosystem will gradually transform into another ecosystem.
- 2 The stony ground in figure 60 shows a pioneer community.

▼ Fig. 60



- 3 One example of a pioneer community in the Netherlands is a deciduous forest.
- 4 A climax community can occur on a barren sand plain over the course of time.
- 5 In a climax community there are many individuals of each species.
- 6 The soil in a climax community has more humus than the soil in a pioneer community.
- 7 A climax community has a more complex food web than a pioneer community.
- 8 The abiotic factors in a climax community are more varied than in a pioneer ecosystem.

OBJECTIVE 9

Answer the following multiple choice questions.

- 1 Adrian and Tony are comparing terrestrial animals to aquatic animals.
 Adrian says that all animals that live in water have streamlined bodies.
 Tony says that all animals that live on land have adapted to carry their own bodyweight.
 Who is right?
 A Neither of them is right.
 B Only Adrian is right.
 C Only Tony is right.
 D Both of them are right.

- 2 Figure 61 shows a hedgehog.
Is a hedgehog an unguligrade or a plantigrade? And are a hedgehog's legs adapted for walking on soft ground or solid ground?

*A hedgehog is Its legs are adapted
for walking on*

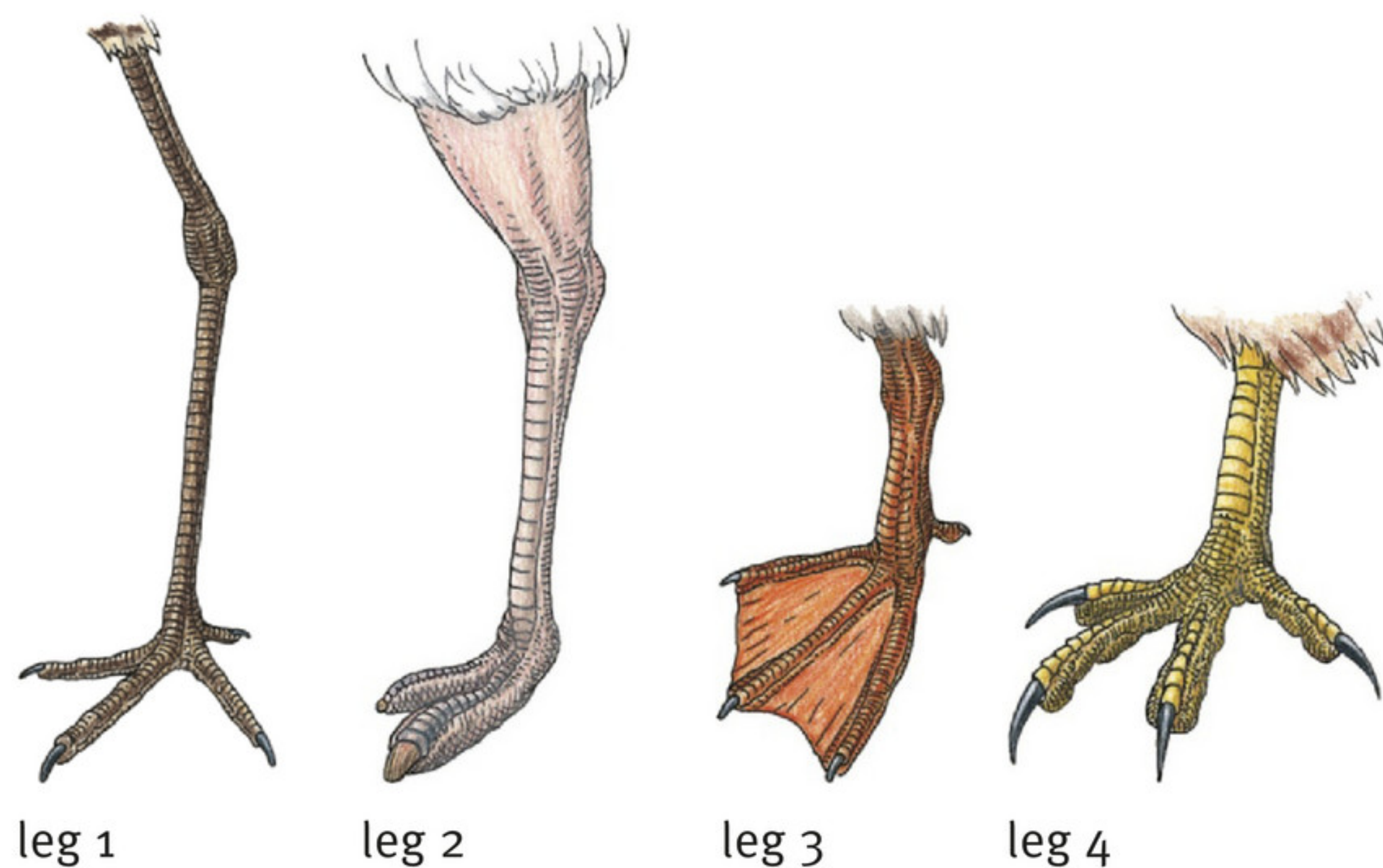
- A** an unguligrade. soft ground.
- B** an unguligrade. hard ground.
- C** a plantigrade. soft ground.
- D** a plantigrade. solid ground.

▼ **Fig. 61** Hedgehog (*Erinaceus europaeus*).



- 3 The drawing in figure 62 shows the legs of four different birds.
Which leg is of a flightless bird? And which is of a bird of prey?
- A** Leg 1 is of a flightless bird and leg 3 is of a bird of prey.
 - B** Leg 1 is of a flightless bird and leg 4 is of a bird of prey.
 - C** Leg 2 is of a flightless bird and leg 3 is of a bird of prey.
 - D** Leg 2 is of a flightless bird and leg 4 is of a bird of prey.

▼ **Fig. 62**



- 4 Figure 63 is a photograph of a bird.
How does this bird use its beak when feeding?
- A** This bird uses its beak to crack open nuts and hard seeds.
 - B** This bird uses its beak to search for worms and molluscs in the ground.
 - C** This bird uses its beak to catch insects.
 - D** This bird uses its beak to filter small plants and animals out of the water.

▼ **Fig. 63**



- 5 Which of the four birds' legs shown in figure 62 could be from the same bird as the beak shown in figure 63?
- A** Bird leg 1.
 - B** Bird leg 2.
 - C** Bird leg 3.
 - D** Bird leg 4.

OBJECTIVE 10

Answer the following multiple choice questions.

- 1 Two features seen in plants are:
- 1 large, flat leaves;
 - 2 a well-developed root system.
- Which of these features are usually found in land plants living in a humid environment?
- A** Neither of them.
 - B** Only feature 1.
 - C** Only feature 2.
 - D** Both of them.

- 2** A cactus is adapted to a dry environment. Two students make a statement about this plant. Mahdat says that the spines of cacti are an adaption to a dry environment. Nadir says that the stems of cacti are an adaptation to a dry environment. Who is right?
- A** Neither Mahdat nor Nadir is right.
 - B** Only Mahdat is right.
 - C** Only Nadir is right.
 - D** Both of them are right.
- 3** During early spring, plants such as wood anemones and celandines bloom in some beech woods (see figure 64). Afterwards these plants wither and the parts above the ground die off. In the spring, one particular abiotic factor is more favourable for these plants than in the summer. Which abiotic factor is more favourable? And how is this factor different in the spring and summer?
- A** The amount of light: more light reaches the forest ground in the spring than in the summer.
 - B** The amount of nutrients: the forest soil provides less nutrients in the spring than in the summer.
 - C** The temperature: the forest soil is warmer in the spring than in the summer.
 - D** The amount of water: the forest soil is drier in the spring than in the summer.

▼ Fig. 64



1 wood anemone



2 celandine

EXTRA OBJECTIVE 11

Use crosses to indicate which of the following characteristics apply to autotrophs and which apply to heterotrophs.

- 1** They have chlorophyll.
- 2** Respiration occurs in the cells.
- 3** Some of the cells can photosynthesise.
- 4** They can create energy-rich compounds from low-energy compounds.
- 5** They require other organisms as their food.
- 6** They take up energy-rich compounds from the environment.
- 7** They take up energy-poor compounds from the environment.

EXTRA OBJECTIVE 12

Answer the following multiple choice questions.

- 1** Various organisms are mentioned in the text for figure 65. Which of these organisms are responsible for capturing the sun's energy in energy-rich compounds?
- A** The beetles and worms.
 - B** The rabbits.
 - C** The birds of prey.
 - D** The grass.

▼ Fig. 65

Edge of a forest

A lot of rabbits live at the edge of a forest. They mainly eat grass. Sometimes a rabbit gets caught and eaten by a bird of prey. The droppings of rabbits and birds of prey serve as food for beetles and worms.



- 2** Young rabbits move around a lot. They also grow well. Two students are talking about it. Pablo says that the energy-rich compounds that the rabbits use for movement get passed on to the next link in the food chain. Ruth says that the energy-rich compounds that the rabbits use for growth get passed on to the next link in the food chain. Who is right?
- A** Neither of them is right.
 - B** Only Pablo is right.
 - C** Only Ruth is right.
 - D** Both of them are right.
- 3** A food chain could be algae → copepods → sticklebacks → pike. Which level of this food chain will contain the greatest quantity of energy-rich compounds?
- A** The algae.
 - B** The copepods.
 - C** The pike.
 - D** The sticklebacks.

- 4** You can often find owl pellets in a forest (see figure 66). Owl pellets contain hair, bones and other indigestible parts of the prey the owl has eaten. An owl has caught and eaten a mouse. Shortly afterwards the owl regurgitates an owl pellet. Does this owl pellet contain energy-rich compounds from the mouse? If so, which organisms can use these energy-rich compounds as building blocks or fuel?
- A** The owl pellet does not contain energy-rich compounds from the mouse.
 - B** The owl pellet contains energy-rich compounds of the mouse that can be used as building blocks or fuel by the owl.
 - C** The owl pellet contains energy-rich compounds from the mouse that can be used as building blocks or fuel by producers.
 - D** The owl pellet contains energy-rich compounds from the mouse that can be used as building blocks or fuel by decomposers.

▼ Fig. 66

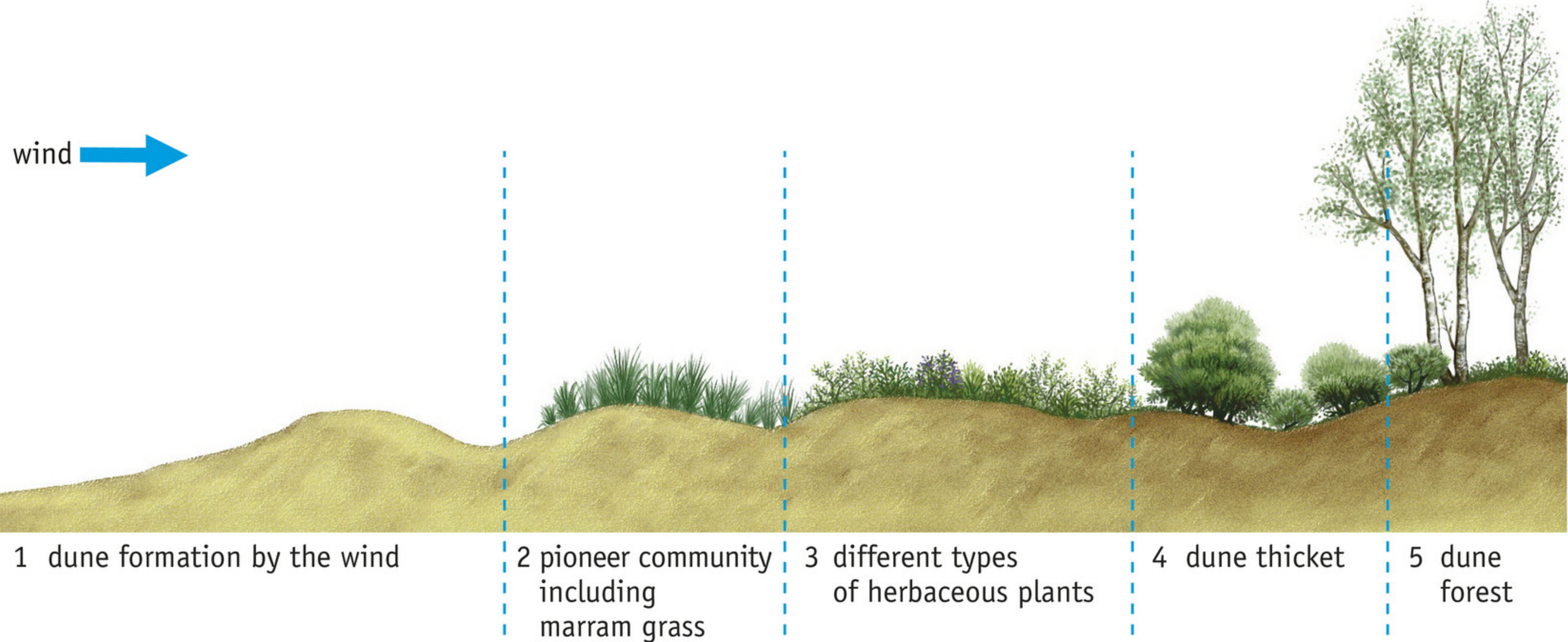


You can do the extension if you have time left over. You can choose between different topics. This unit’s extension consists of three topics. You should do the exercises in your workbook.

1 Ecosystems in the Netherlands

There are lots of ecosystems in the Netherlands: dune areas, deciduous woods, coniferous woods, heathland, lakes, fields, ditches, rivers, the Wadden region and so forth. In this extension, you will learn more about several of these ecosystems. You have to answer questions and complete a table.

▼ Fig. 67 Stages of succession in a dune area.



DUNES

Dunes are sand hills that were formed by the wind. You can often find various stages of succession in dune areas (see figure 67). The stages are easiest to distinguish by the plant growth.

The first plants are able to cope with the harsh conditions. When the sand and dust covers them, they must grow out of the sand again. They must also be able to live with only very little humus in the soil. Only a few plants can tolerate this. The first species that appear are types of **grass**, including marram grass (see figure 68). These grasses are part of the pioneer community in a dune area. Once the first grasses have become established, the sand does not get blown away as much and the amount of humus in the soil gradually increases. The pioneer community gets replaced by another ecosystem in which various types of **herbaceous plants** can grow. This stage takes some time. Sometimes this stage of succession gets disrupted, for example when rabbits dig burrows or when a storm covers the plants in a thick layer of sand. Succession then starts over again with the pioneer community.

▼ **Fig. 68** European marram grass.▼ **Fig. 69** Dune thicket.▼ **Fig. 71** Coniferous forest.

Over the course of time shrubs start growing, especially buckthorn bushes. We call this vegetation the **dune thickets** (see figure 69). This is the third stage of succession.

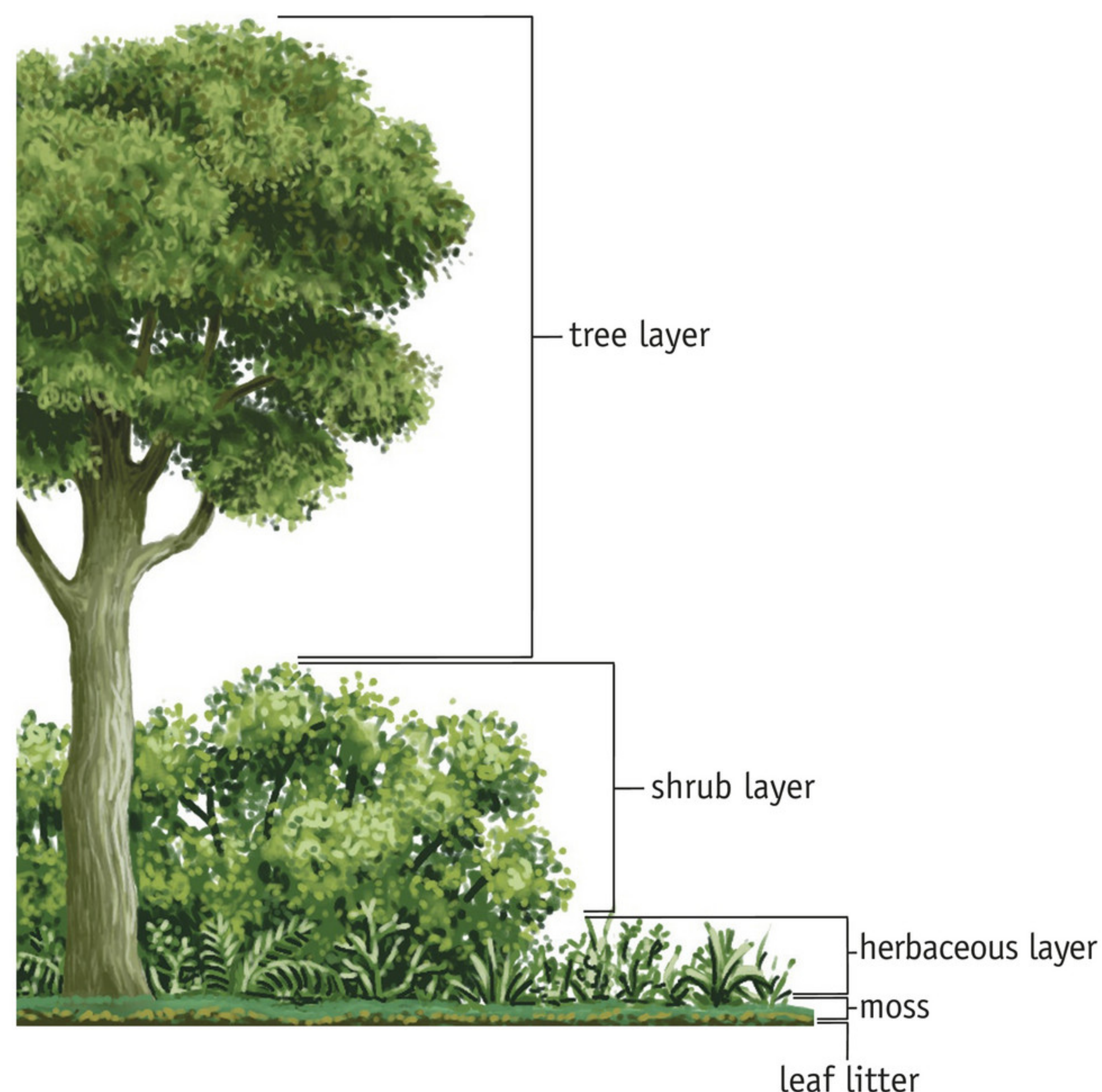
Finally the climax community gets established: a **dune forest** with birch trees, willows and elderberries.

DECIDUOUS FOREST

Deciduous forest is the natural climax community in most of the Netherlands. In deciduous forests, plants grow in different layers (see figure 70). There is leaf litter on the forest ground. Many small animals live in this leaf litter.

Just above the leaf litter is the moss layer, which is only a few centimetres thick. Mosses and toadstools grow in this layer, for instance. Above the moss layer is the herbaceous layer. Ferns, blueberries and various herbaceous plants grow here.

The shrub layer is above that, and at the very top is the tree layer with the crowns of the trees. There is competition between the four layers for sunlight and for getting as many seeds as possible to germinate on the ground.

▼ **Fig. 70** The layers in a deciduous forest.

CONIFEROUS FOREST

Coniferous forests are not native to the Netherlands. Any coniferous forests you see have been planted. Conifers grow faster than deciduous trees. The layers in coniferous forests are different to the layers in deciduous forests (see figure 71). Coniferous forests have far fewer species than deciduous forests.

2 Leaf litter

In many ecosystems the soil is covered by a layer of fallen branches and leaves. We call that **leaf litter** (see figure 72). Many small animals live in the topsoil and leaf litter. On warm days in particular you can find a lot of animals. In this extension you will investigate the leaf litter and topsoil for small ground-dwelling animals. You will carry out this study in a group. You can carry out this study in different ecosystems around your school, such as a wood, a meadow, a field or a park.

▼ Fig. 72 Leaf litter.



▼ Fig. 73 An app for looking up animals with.



In the ecosystem, you will take a **sample** of the leaf litter and the topsoil. In class you will collect the small animals in the soil from your sample. Try to discover the names of the small animals you found. You can use an identification key, a reference book, the Internet or an app.

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3 Living together

Within a population, each individual has relationships with a large number of members of its own species. In these relationships, we can distinguish between **competition** and **cooperation**. There is competition for food, finding a mate or a safe place.

RELATIONSHIPS WITHIN A POPULATION

There is often competition between individuals of a species. Animals that live in groups often have **ranking systems**. There are fewer fights then because each individual knows its own place. Having a territory also reduces the chance of fights. A **territory** is an area that is defended against members of the same species. A territory can serve as a hunting ground, for example, or also as space for rearing young animals.

Individuals of a species may also cooperate, for example to hunt prey. To reproduce, animals form **pairs**. This allows males and females to cooperate in order to reproduce. Some species form new pairs every year, but in other species the pairs stay together for their entire lives. This is the case in swans, for example (see figure 74).

RELATIONSHIPS BETWEEN POPULATIONS

There is often not much competition between individuals of different populations, because the species specialise. Common kestrels, little owls and long-eared owls all eat field mice, but the common kestrel hunts during the day, little owls hunt in twilight and long-eared owls hunt at night (see figure 75).

▼ Fig. 74



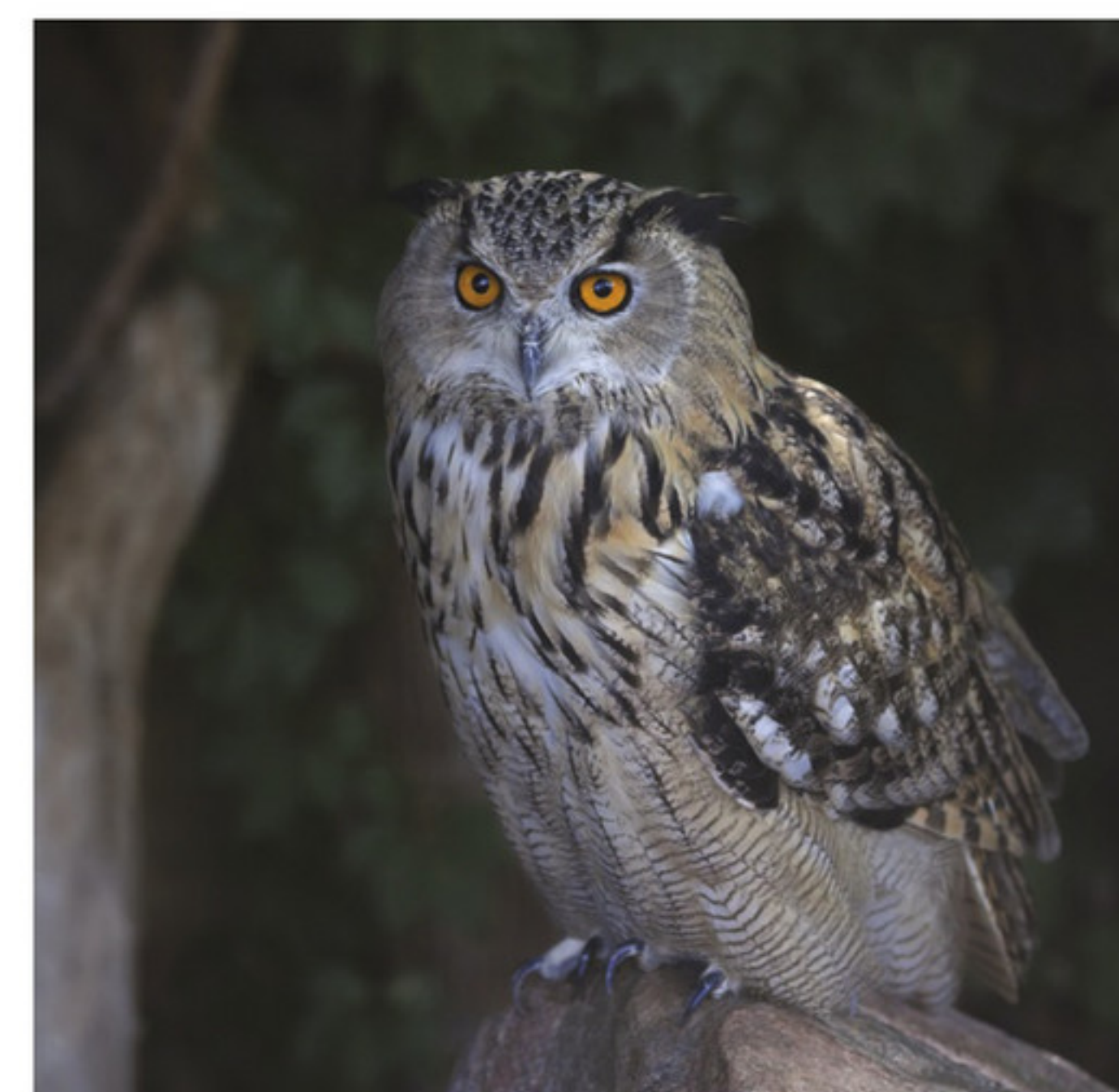
▼ Fig. 75



1 kestrel: hunts during the day



2 little owl: hunts at dusk



3 long-eared owl: hunts at night

Individuals of different species can maintain long-term relationships. Living together like this is called **symbiosis**. There are different forms. Both species can benefit from the symbiosis. This is called **mutualism**. You can find this in lichen, where a fungus lives together with an alga (see figure 76). Other forms of symbiosis benefit only one of the two individuals. If the other individual has neither an advantage nor a disadvantage, it is called **commensalism**. An example of this is the green algae on a tree trunk. If one of the individuals is disadvantaged by the relationship, it is called **parasitism**. That is when one individual, the **parasite**, lives on or in an individual of a different species, the **host**. Parasites can be animals, plants or fungi (see figure 77).

WB EXERCISES 1 AND 2, PAGE 77

► **Fig. 76** The structure of a lichen.

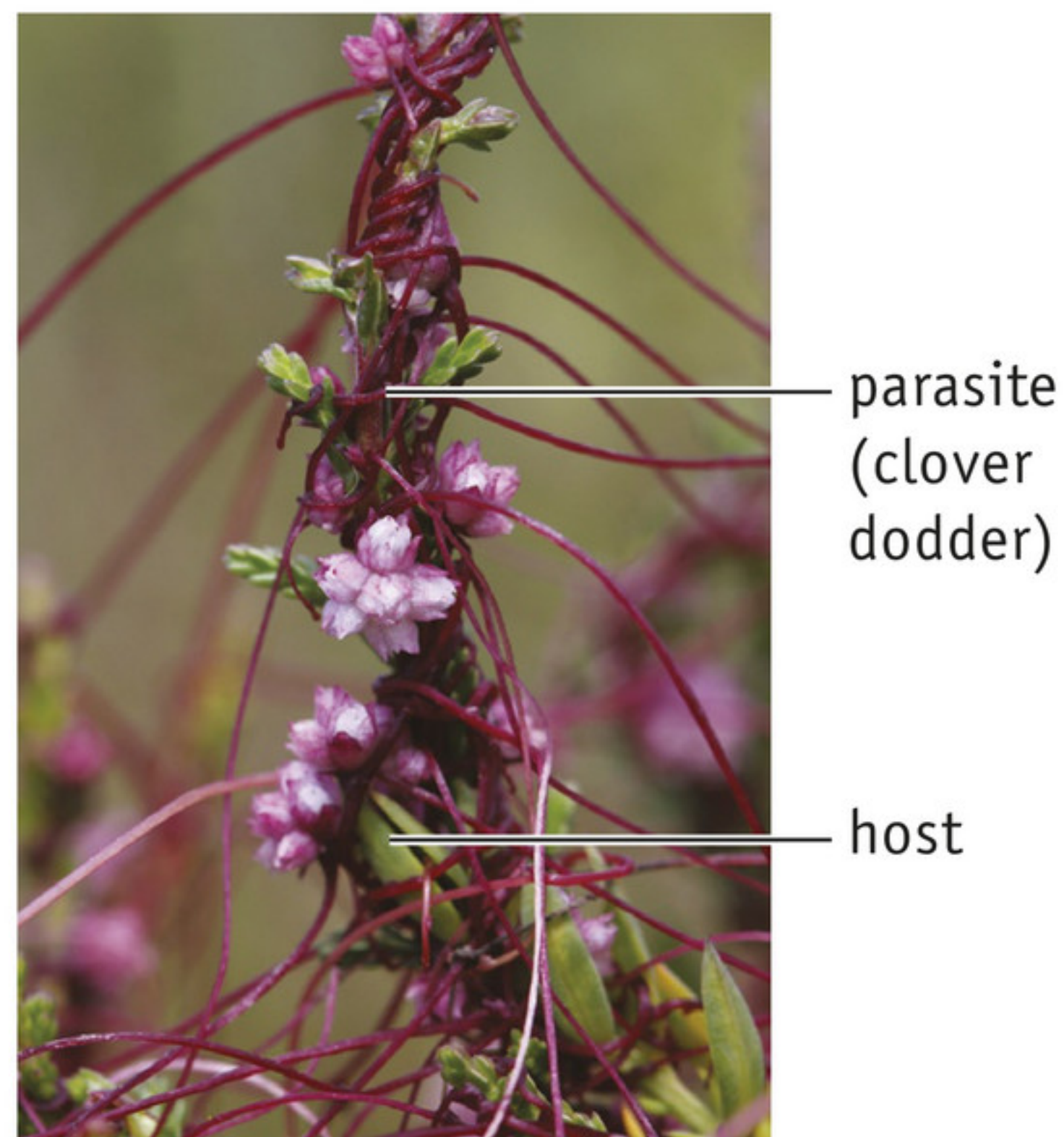


▼ **Fig. 77**



1 Lice

These insects feed on the blood of humans and lay eggs (called nits) that stick to the hairs.



2 Clover dodder

The plant does not have its own chlorophyll. It uses its roots to take energy-rich compounds from the vessels of its host.



3 Athlete's foot

The fungus grows mostly on the skin between the toes. It lives on energy-rich compounds in the epidermis.

7

Humans and the environment



BASICS

- 1 Humans and the environment
- 2 Energy
- 3 The greenhouse effect
- 4 Clean air
- 5 Waste
- 6 Food production

EXTRA

- 7 Control of pests and diseases
- 8 Water and soil

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- 1 Litter 176
- 2 Measures for protecting the environment 179
- 3 Preparing a soil profile 181



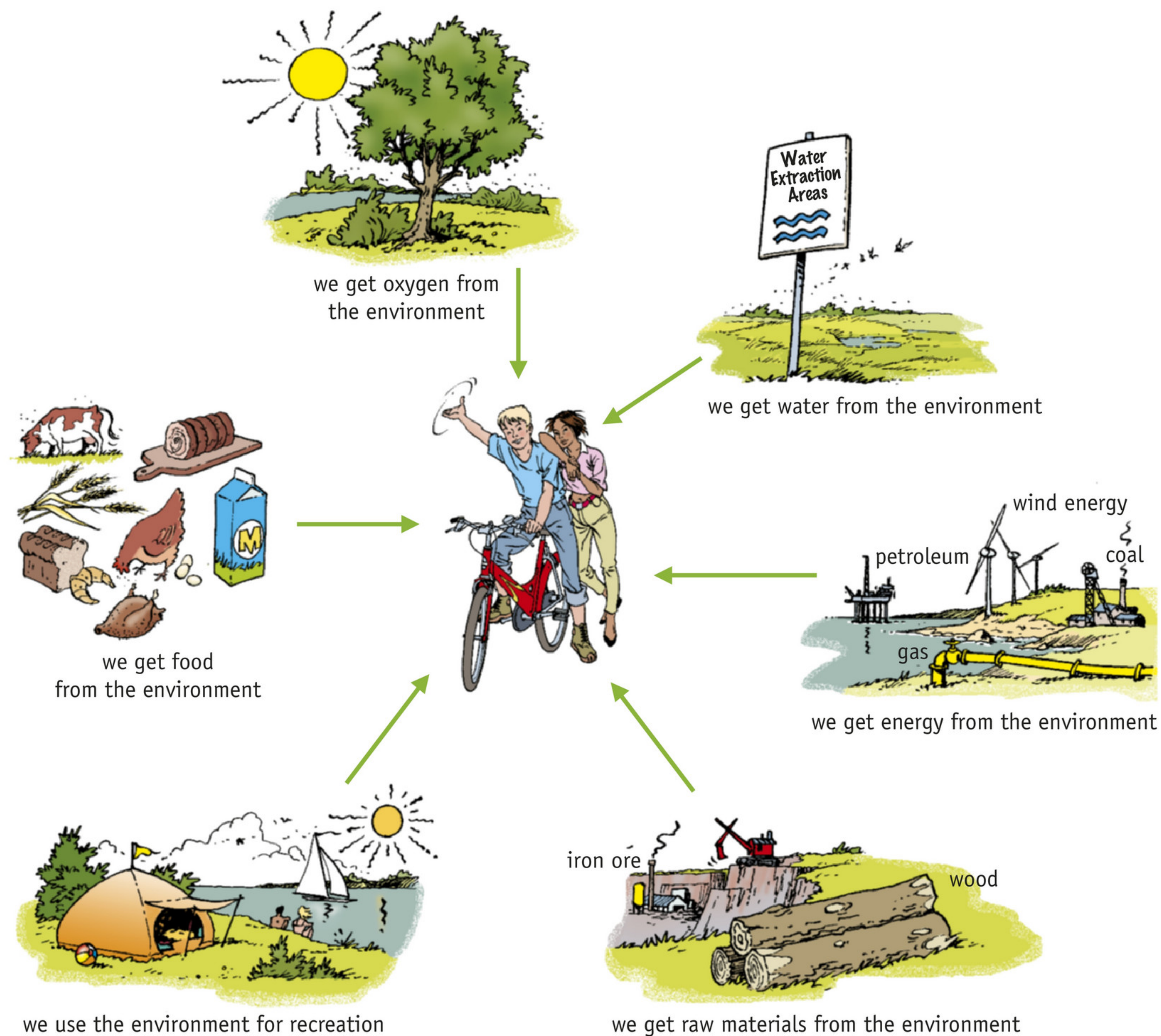
This unit is called 'Humans and the environment'. Humans depend on the environment, but they also have an impact on it. People are not always careful with the environment. That is how environmental problems arise. This unit teaches you what the main causes and consequences are of those environmental problems. More and more people are realising how important it is to have an unpolluted environment. You will learn what is being done to protect the environment. You will also learn how you too can help protect the environment.

When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

1 Humans and the environment

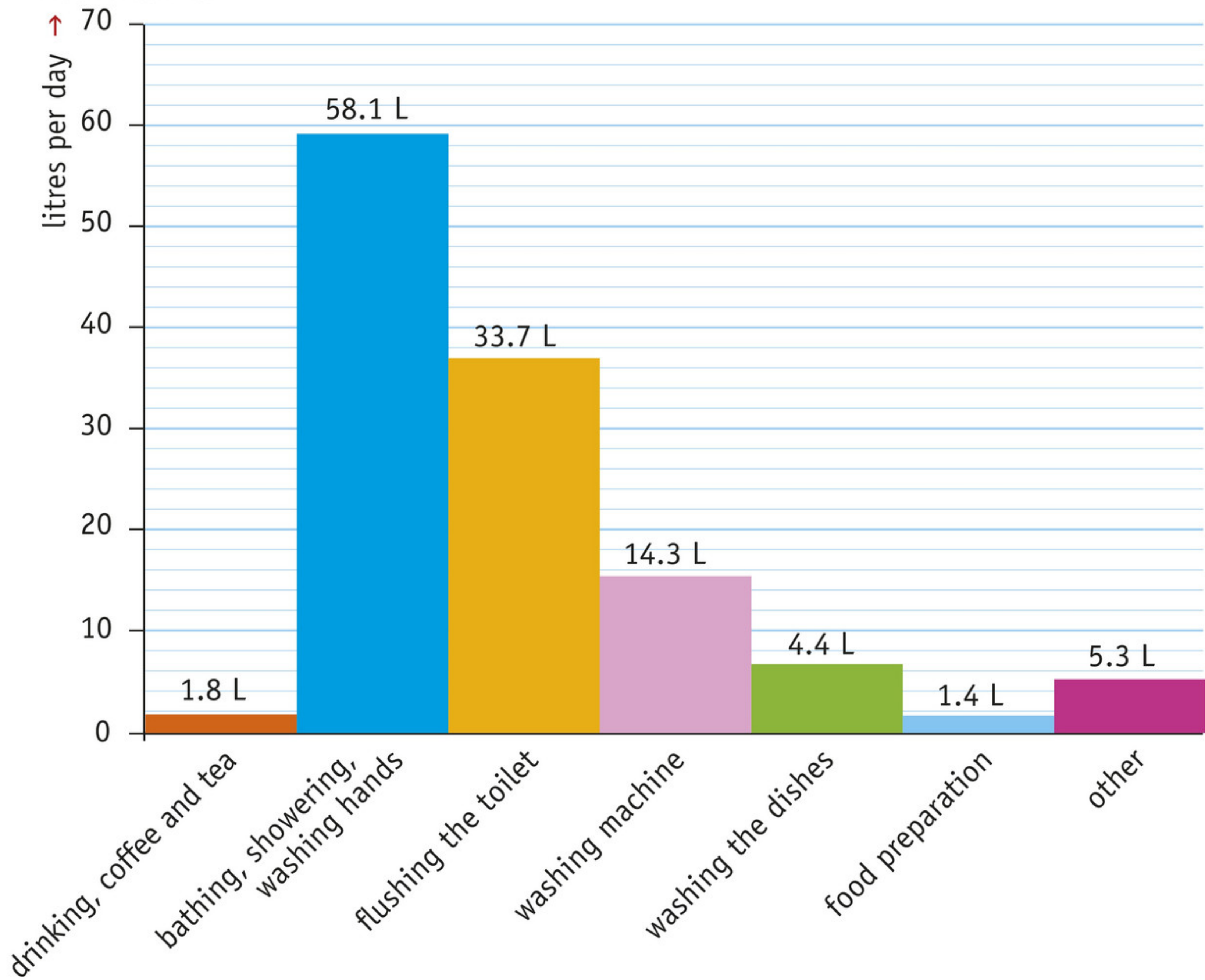
▼ **Fig. 1** Humans depend on the environment.

The environment has an influence on humans. Like all other organisms, people depend on the environment (see figure 1).



The environment gives people food to eat, oxygen to breathe and water for drinking, washing or flushing the toilet (see figure 2). We also get energy from the environment, for example for cooking, heating our homes and operating machinery. The environment also provides raw materials. Raw materials are used for making products. Iron ore is used to produce steel, petroleum is used to make plastics and silkworms produce silk (see figure 3). Some plants and animals also supply the raw materials for medicines.

▼ **Fig. 2** Water consumption in the Netherlands.



▼ **Fig. 3** Silkworms produce the raw materials for silk fabrics.



Finally, the environment is important as a place for recreation. A lot of people use the environment as somewhere to relax. People like spending their free time in the countryside, for example hiking, fishing or swimming (see figure 4).

WB EXERCISE 1, PAGE 80

► **Fig. 4** The environment as a place for recreation.

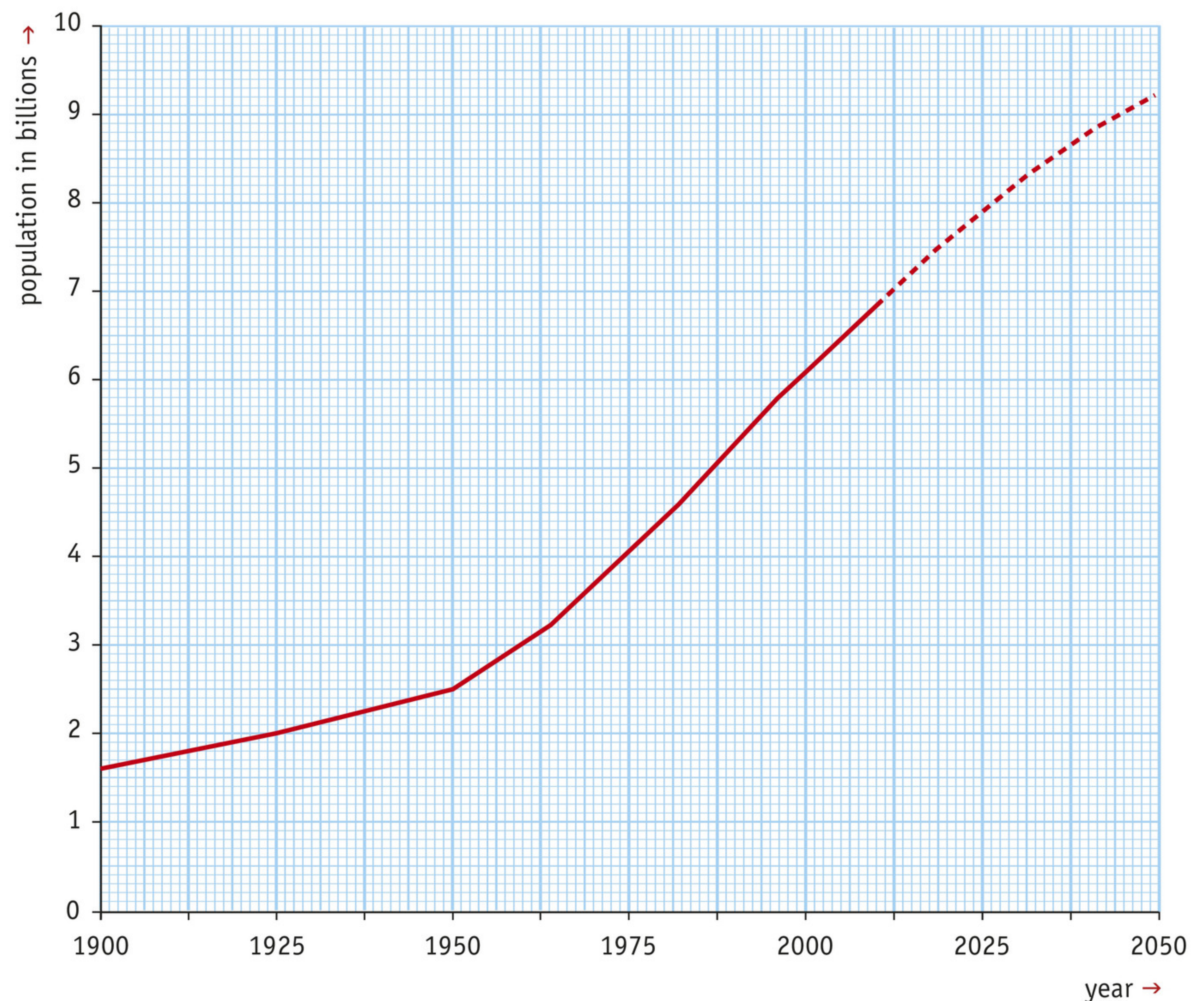


IMPACT ON THE ENVIRONMENT

People have an impact on the environment. We change the environment because we remove certain substances from the environment and add other substances to it. If there were only a few people living on the planet, people would not have much of an impact on the environment. These days, people's activities often cause environmental problems. **Environmental problems** arise because people add substances to the environment that lead to **pollution** or because they remove so many substances from the environment that a resource becomes **depleted**. Pollution and depletion result in **damage** to the environment.

The main causes of environmental problems are population growth and people's lifestyles. The global population has grown a lot in the last hundred years and will continue to grow in the years to come (see figure 5). This growth means that more and more food is needed and so more land for agriculture is also needed. All those people also have to live somewhere and they need roads to get around. A lot of land is also needed for those houses and roads. Now that people are using so much land, many plants and animals are losing their natural habitats.

▼ **Fig. 5** Growth of the global population since 1900 and the expected growth through to 2050.



▼ **Fig. 6** We use a lot more electrical appliances nowadays.



1 in the past



2 now

▼ **Fig. 8**

Toxicology analyst

Hello. My name is Chantal and I'm a toxicology analyst. I study the safety of substances that humans are or might be exposed to. We study how cells and tissues react to different concentrations of the substances we test. I build and operate test setups for studying the impact of gases, liquids and solid substances. The other day we had to examine unknown substances from barrels that were found in a wood. The barrels turned out to come from an illegal laboratory for making XTC. More and more research is being done into drug-related waste. In 2013, for instance, the police found twice as much drug-related waste that had been dumped as in 2012.



People have changed their lifestyles in the past hundred years. In the past, for example, people used to travel by horse and cart but now nearly every family has a car. That has made it possible to travel much greater distances. We also have more and more electrical appliances, such as vacuum cleaners, washing machines, fridges, computers, tablets and mobile phones (see figures 6 and 7). All these appliances and vehicles need energy, as do the factories where they are produced. A lot of fuel is needed to generate the electricity and that process releases a lot of waste products. The waste products pollute the environment.

▼ **Fig. 7** Mobile devices are an integral part of our everyday lives.



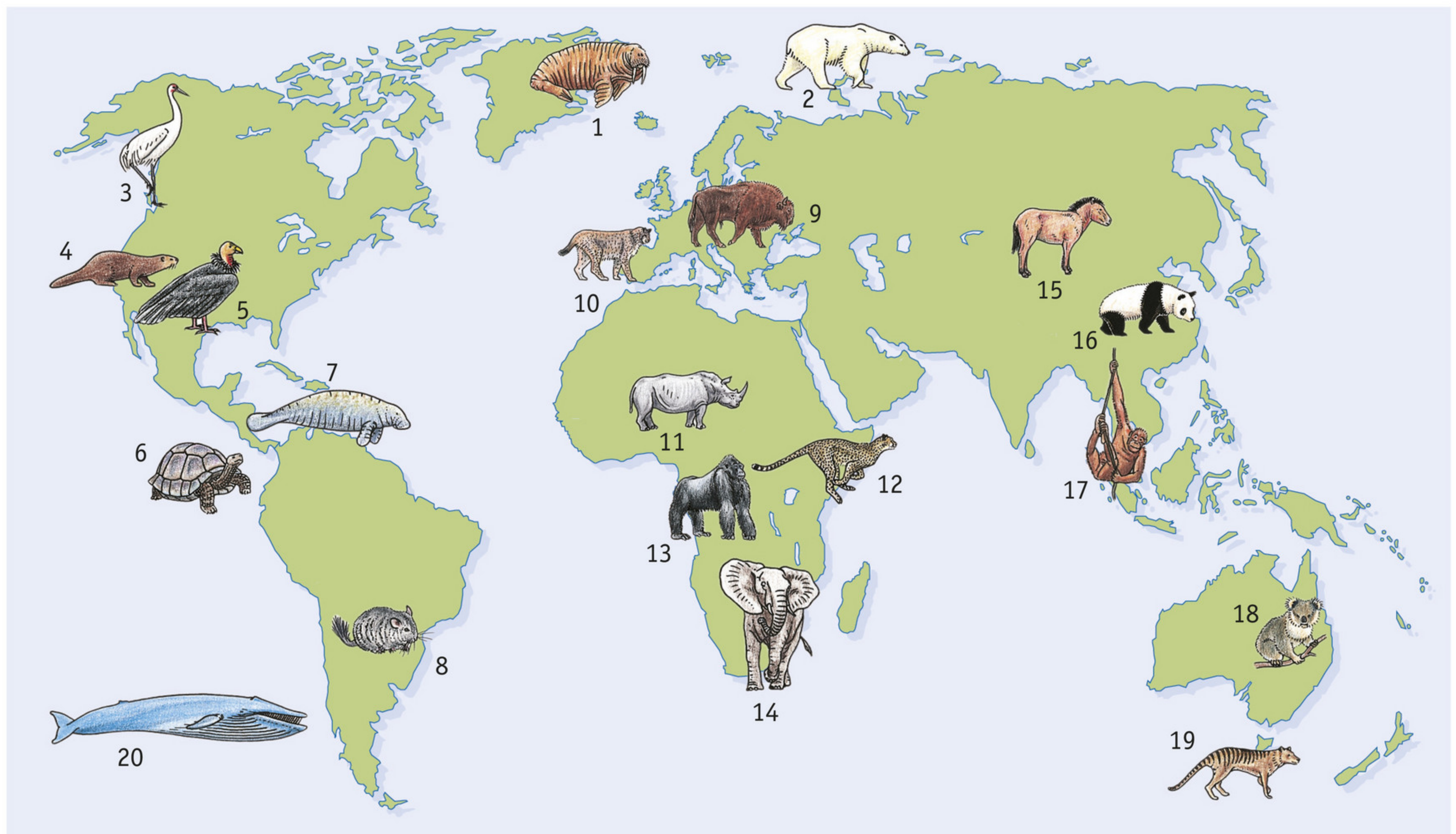
Stocks of energy are being used up because people are consuming lots of fuel for transport and for generating energy. We say that the **energy sources** are becoming depleted. Large amounts of raw materials from the environment are needed to produce all the machinery and appliances. The stocks of these **raw materials** are therefore also becoming depleted. When the machines and appliances are no longer usable, they end up as waste. This waste can be harmful to the environment, or even toxic. A **toxin** is a substance that has a harmful effect on an organism. A toxicology analyst is someone who examines how toxins work (see figure 8).

In the **chemical industry**, toxic waste is often produced when making plastics, medicines, washing powder and paint. The government checks whether this toxic waste is being processed safely. Sometimes toxic substances still end up in the environment, which leads to environmental pollution.

BIODIVERSITY

The natural habitat of many plants and animals has disappeared due to human activity. Hunting and fishing have also caused various species of plants and animals to die out. Many other species are threatened with extinction (see figure 9).

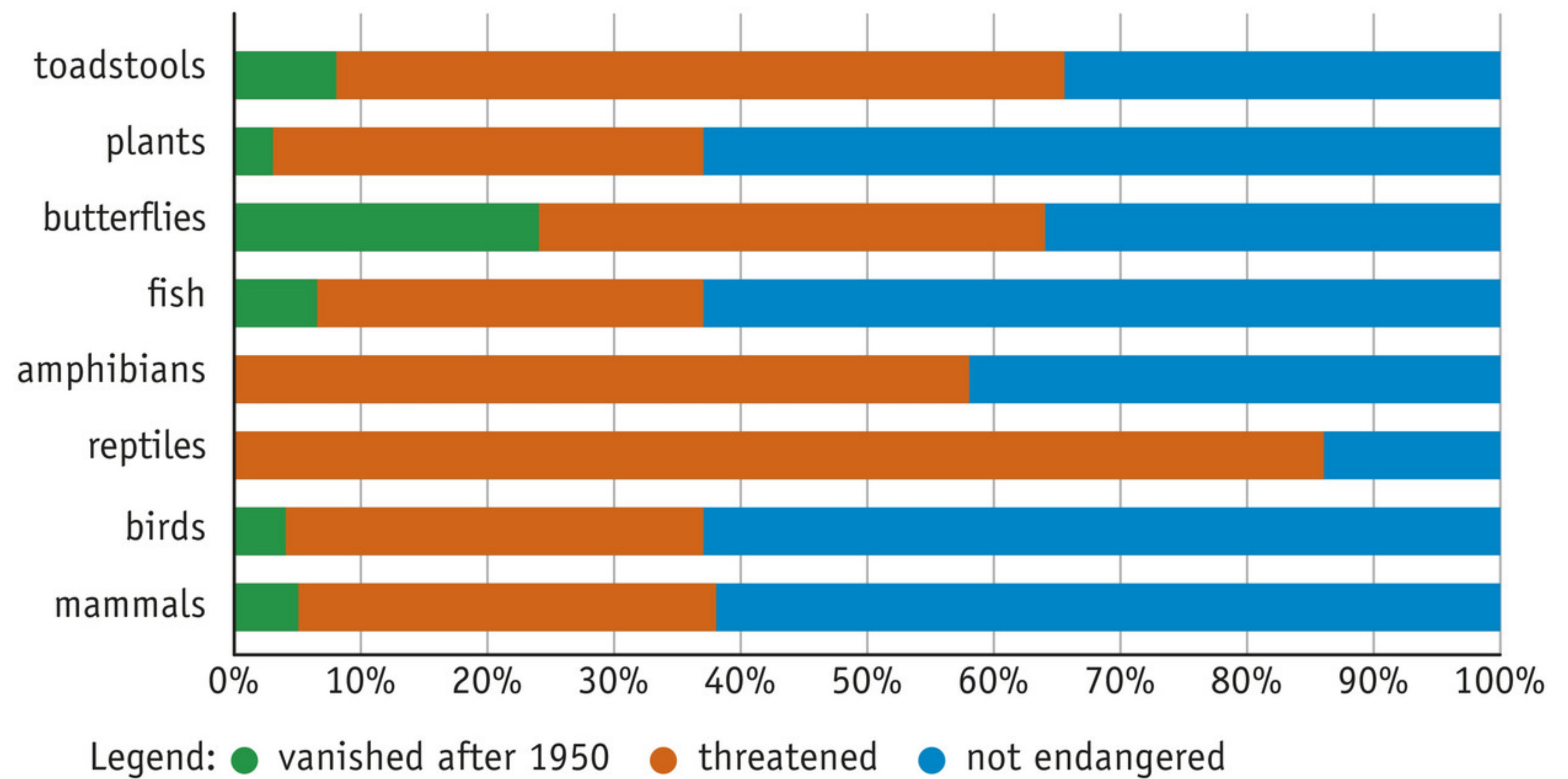
▼ **Fig. 9** A number of endangered animal species.



Legend:

- | | |
|------------------------|-----------------------|
| 1 = walrus | 11 = white rhinoceros |
| 2 = polar bear | 12 = cheetah |
| 3 = whooping crane | 13 = mountain gorilla |
| 4 = sea otter | 14 = African elephant |
| 5 = Californian condor | 15 = Przewalski horse |
| 6 = giant tortoise | 16 = giant panda |
| 7 = manatee | 17 = orang-utan |
| 8 = chinchilla | 18 = koala |
| 9 = bison | 19 = Tasmanian wolf |
| 10 = Iberian lynx | 20 = blue whale |

► **Fig. 10** Endangered species in the Netherlands.



The number of different ecosystems around the world is decreasing. As a result there is less and less variation in nature and the environment is becoming increasingly uniform. In unit 6 you learned that the variation in species in nature is called **biodiversity**. Biodiversity is decreasing due to the impact of people.

Protective measures are used to try to increase the populations of endangered species. For example, the stork population in the Netherlands was in serious trouble. That is why a project was started in 1969 to increase the number of breeding storks (see figure 11). There have also been projects for reintroducing beavers and otters in the Netherlands (see figures 12 and 13). **Reintroduction** means bringing an animal or plant species back to a country.

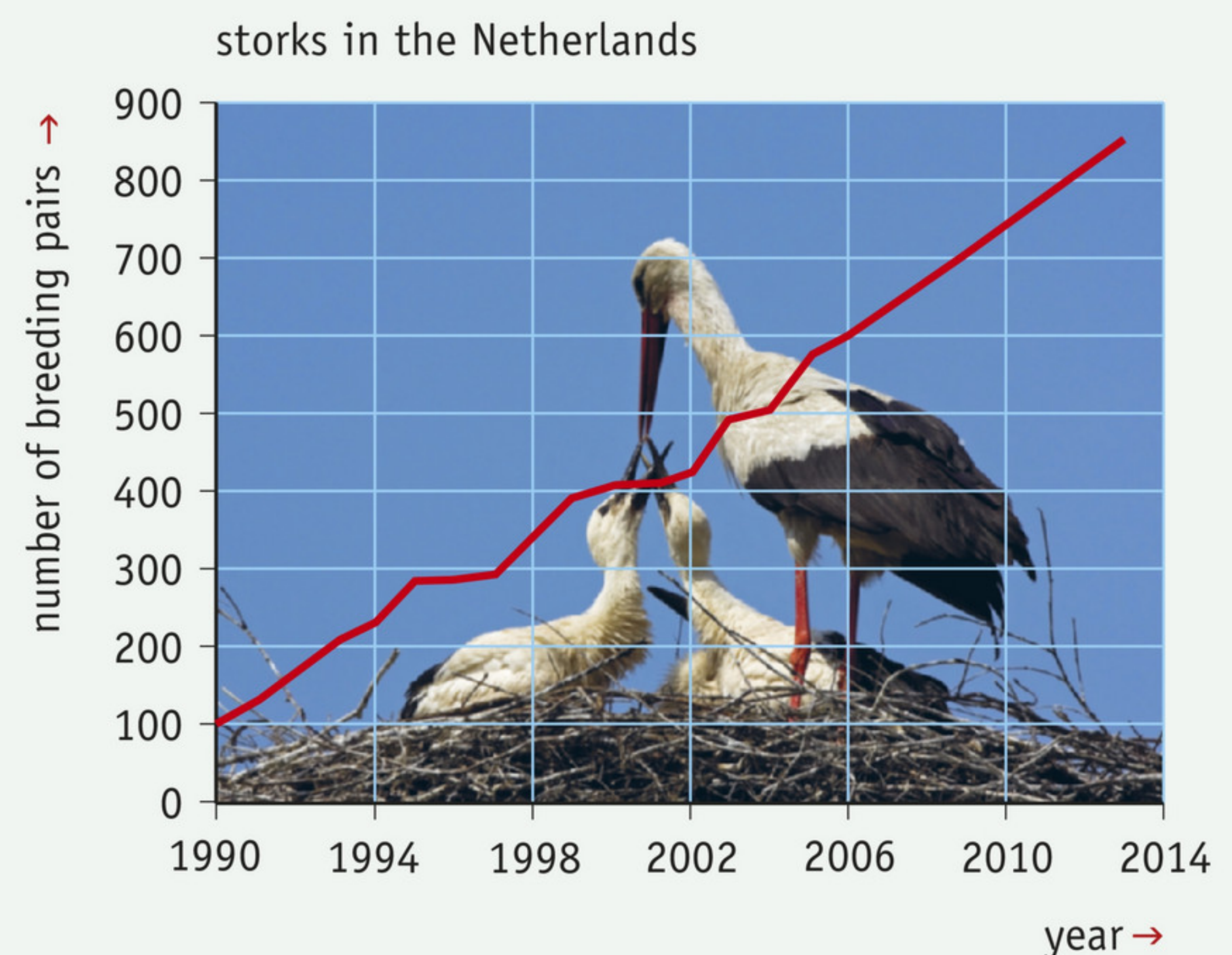
WB EXERCISES 2 TO 5, PAGE 80

▼ **Fig. 11**

Stork nearly vanished

When counted for the first time in the Netherlands, in 1910, there were roughly five hundred occupied stork nests. The number was already decreasing. In the 1940s there were three hundred to three hundred and fifty breeding pairs. In the 1960s the stork had nearly vanished from the Netherlands as a breeding bird: in 1960 there were 48 nesting pairs left and in 1970 there were only fourteen left. Not all of these nesting pairs were also breeding pairs.

To turn the tide, a reintroduction programme for storks was started in 1969. By 2004 the number of breeding pairs was back at the same level as 1910. Since 2004, the stork has no longer been on the list of endangered bird species. In 2013 there were eight hundred and fifty breeding pairs. But the stork is not fully independent yet: many breeding pairs rear their young with human help.



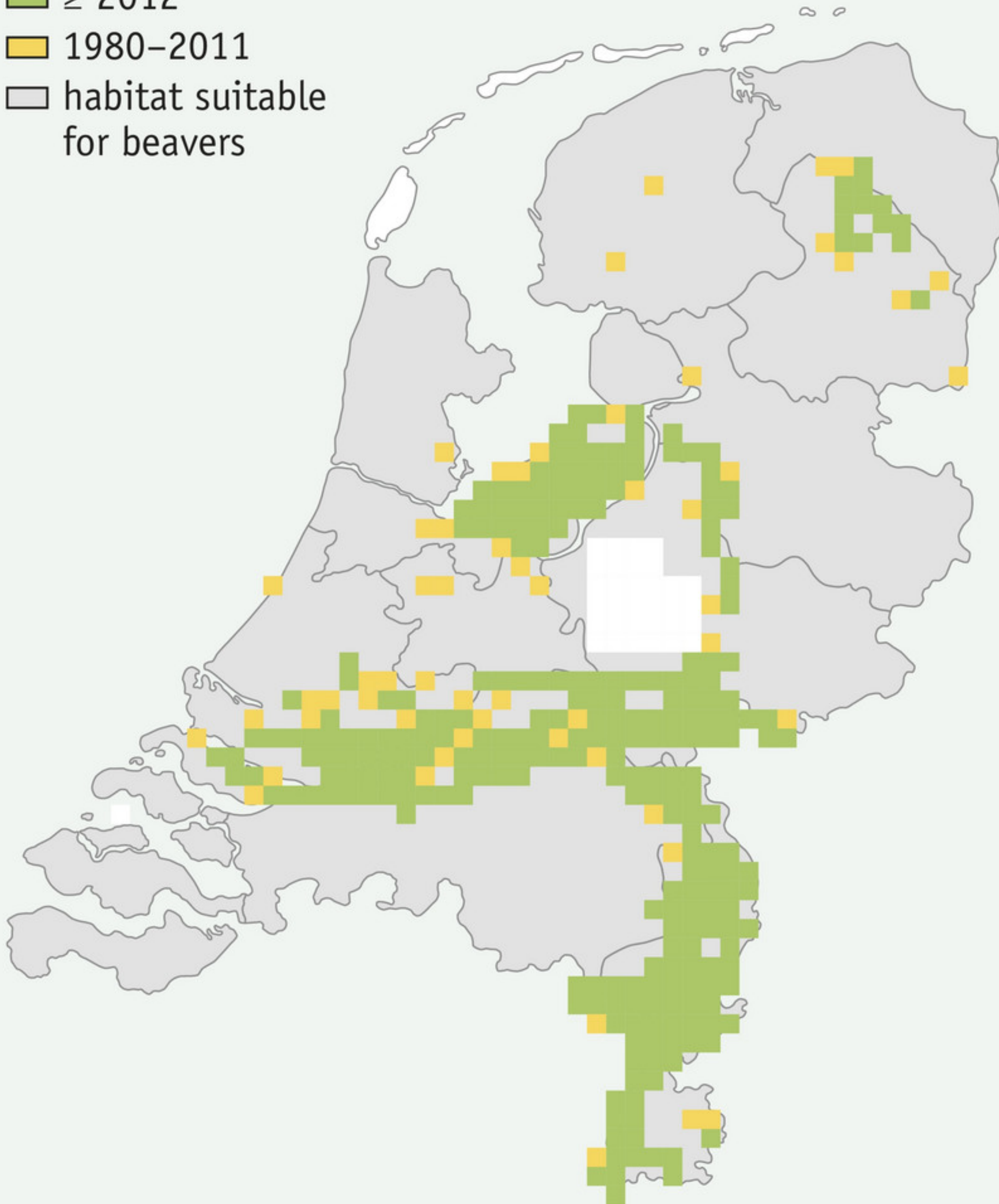
▼ Fig. 12

Reintroduction of beaver very successful

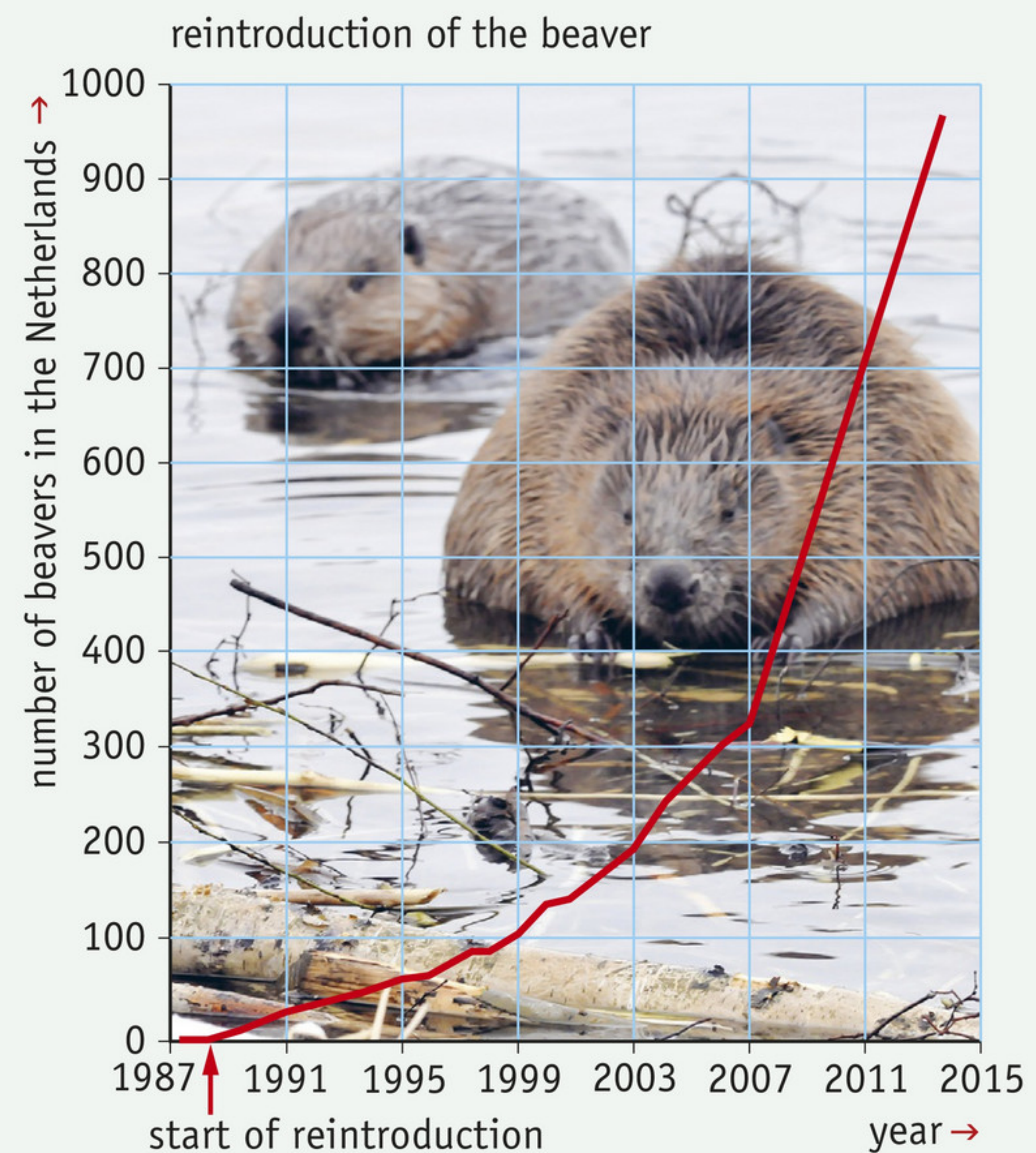
At the beginning of the nineteenth century, beavers were very common in Europe, including the Netherlands. They were heavily hunted for their fur and meat. In 1826, the country's last beaver was killed near the IJssel river. By around 1900, the beaver had almost completely vanished from Europe. Thanks to protective measures and relocations, the beaver has returned to many countries.

distribution of beavers (*Castor fiber*) in 2013

- ≥ 2012
- 1980–2011
- habitat suitable for beavers



Between 1988 and 2005, a total of 144 beavers were released in the Netherlands. The number of beavers in the Netherlands is now estimated at roughly nine hundred to a thousand. It is expected that beavers will keep on spreading and that their numbers will keep growing in the coming years.



▼ Fig. 13

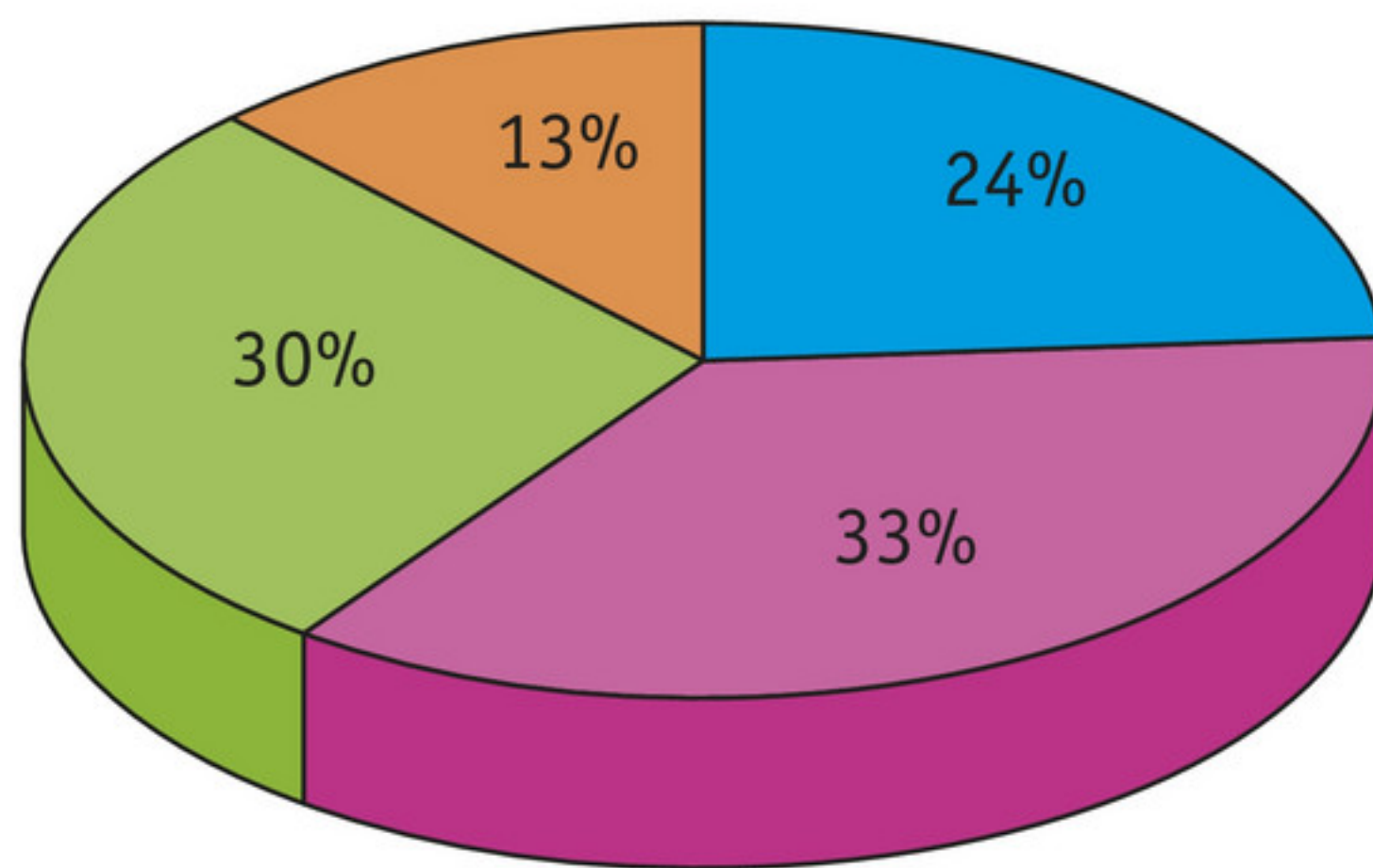
Reintroduction of the otter in the Netherlands

The otter was declared extinct in the Netherlands in 1988. Between 2002 and 2008, a total of 31 otters were reintroduced in and around the Weerribben-Wieden nature reserve. There are now roughly fifty to sixty otters again in the Netherlands. Many of these otters are related to each other. In 2013, to prevent weakening of the otter population, two female otters were released that were not related to the otters released in the Netherlands earlier.



2 Energy

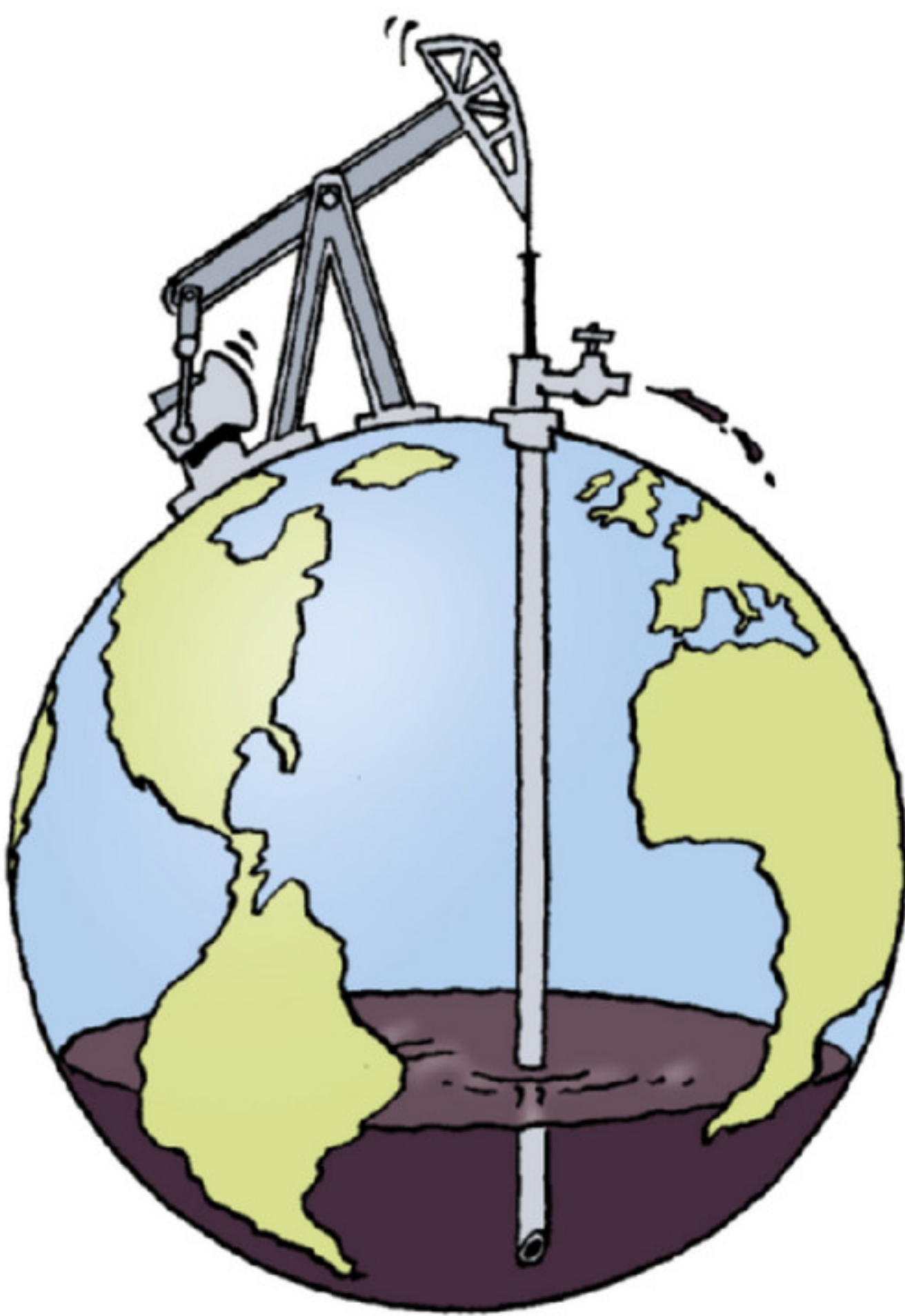
▼ **Fig. 14** The most important energy sources in the world.



Legend:

- natural gas
- petroleum
- coal
- other

▼ **Fig. 15**



The demand for energy has grown a lot in the last two hundred years due to the changes in our lifestyles. Natural gas, petroleum and coal are our main energy sources (see figure 14).

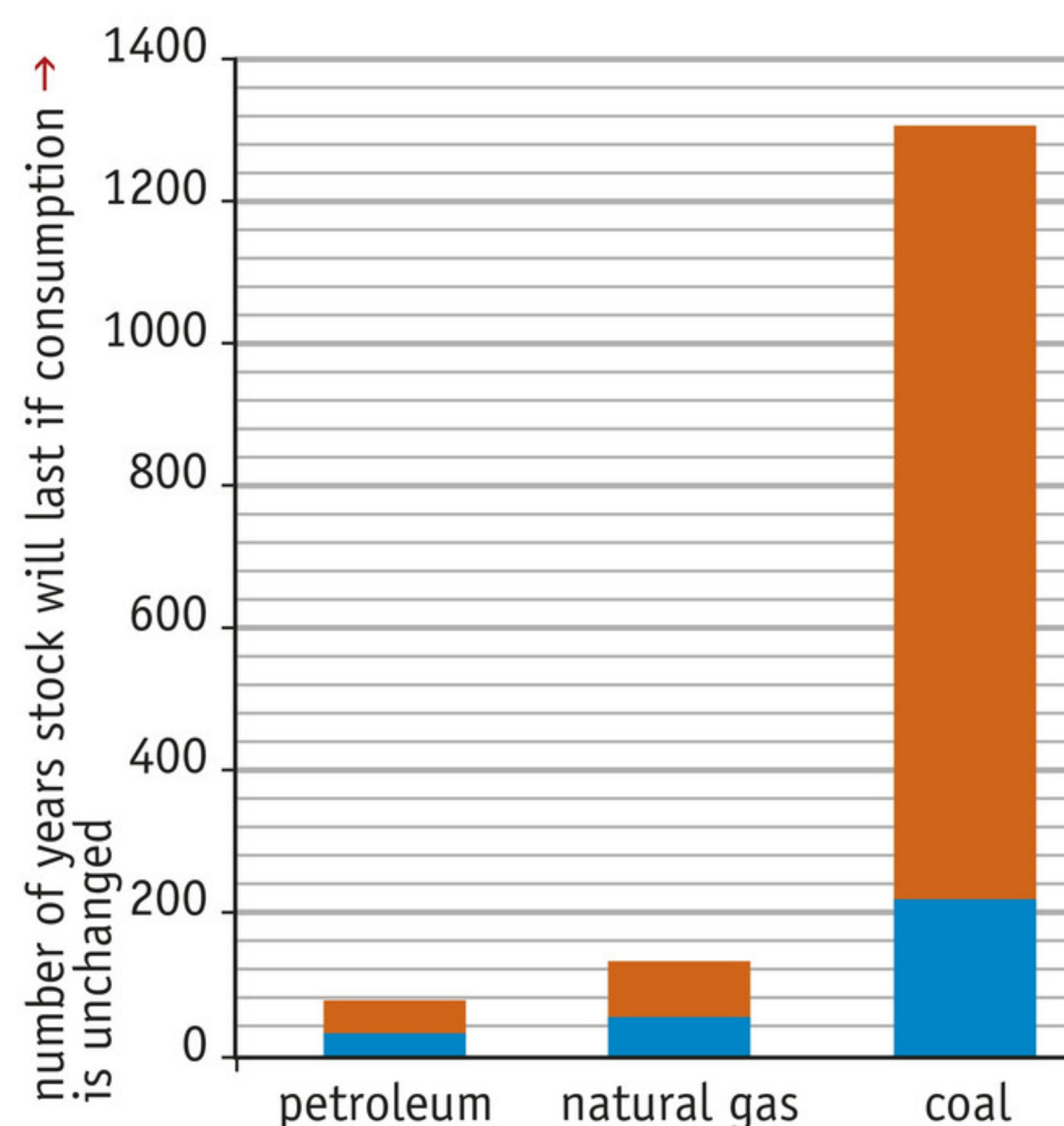
FOSSIL FUELS

Natural gas, petroleum and coal were created millions of years ago from the remains of dead plants and animals. We therefore call them **fossil fuels**. You have learned about photosynthesis, the process in which plants use the energy from sunlight to produce glucose. When they do this, plants absorb carbon dioxide from the air. Plants can make all kinds of other substances from glucose, including the substances that they themselves are made of. The energy in the remains of dead plants (and therefore in fossil fuels) ultimately comes from the sun. This energy is released during the combustion of the fossil fuels. We can use the energy to operate vehicles, heat our homes or produce electricity. This also produces carbon dioxide. Fossil fuels are relatively cheap to extract from the ground and easy to transport and consume.

But there are big disadvantages to the consumption of fossil fuels. The carbon dioxide released during combustion is one of the causes of **global warming**. Another disadvantage is that the combustion of coal and petroleum in particular releases waste products that cause **air pollution**. You will learn more about this in basics 3 and 4.

Because we use a lot of fossil fuels, stocks of fossil fuels are becoming depleted. It is expected that the stocks of petroleum, natural gas and coal will be depleted in the not too distant future (see figures 15 and 16).

▼ **Fig. 16** How much longer will the Earth's stocks of fossil fuels last?



- Legend: ● directly extractable reserves
● extra stocks that are difficult to extract

▼ **Fig. 17** The nuclear disaster at Fukushima.



NUCLEAR POWER

The fuel for nuclear power is uranium. In a nuclear power station, atomic nuclei of uranium are split apart. This releases a lot of energy in the form of heat. This heat is used in a nuclear power station to generate electricity. The advantage of nuclear power is that it does not cause air pollution and no carbon dioxide is released.

A major disadvantage of nuclear power is radioactive waste. The radiation from radioactive waste can be harmful and even fatal for people and nature. In the past, all the waste used to be stored up, but nowadays 95% is being reused. The remaining 5% is vitrified (which means that it is mixed into glass) and then stored. It then remains hazardous for about ten thousand years. The Netherlands does not produce a lot of radioactive waste: less than half a gram per family per year. For the Netherlands as a whole this is not more than a large refrigerator.

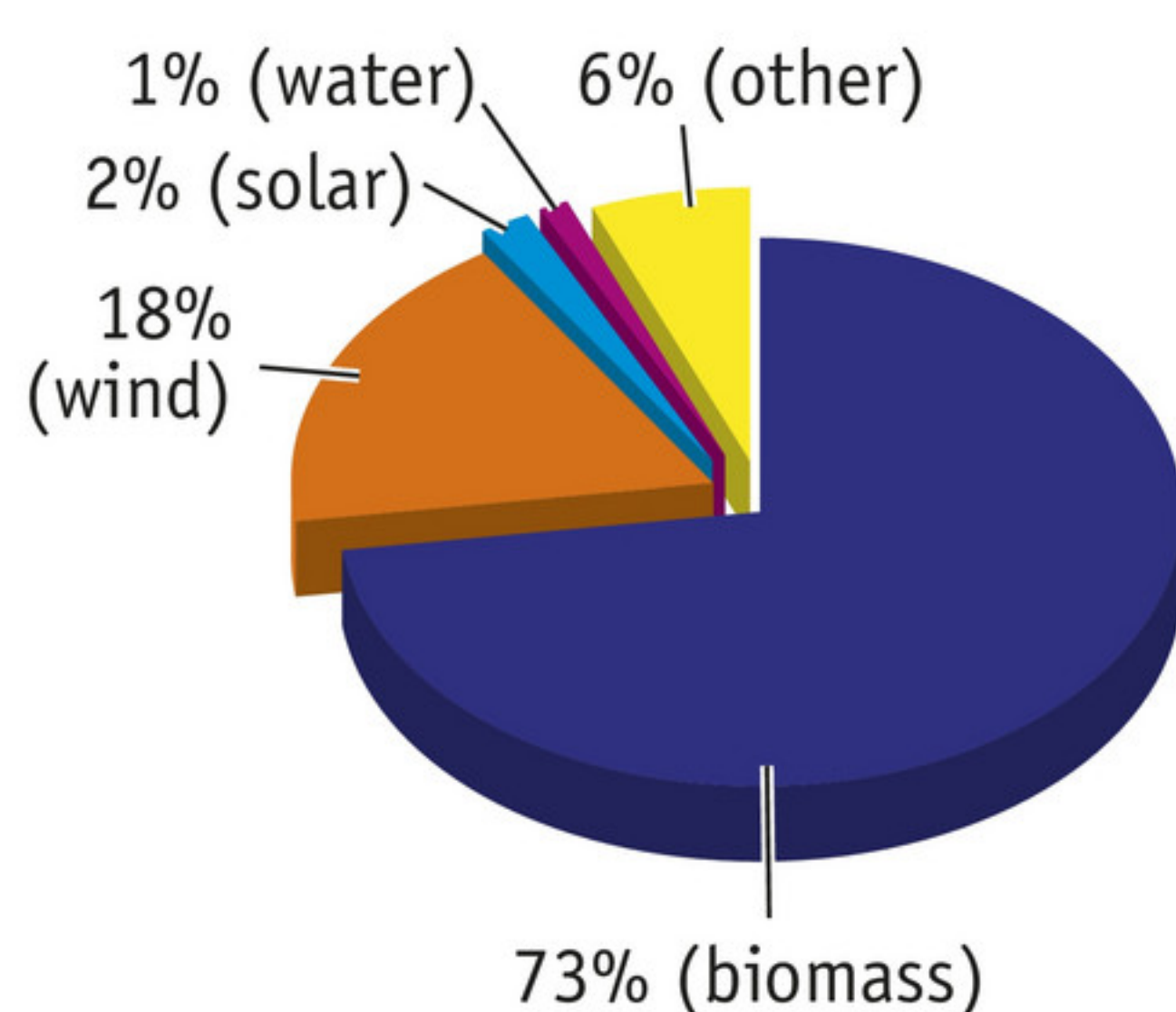
Accidents in nuclear power stations can have disastrous consequences. An example is the nuclear disaster in Fukushima in Japan in 2011, when a lot of radioactivity was released (see figure 17). Because of the radioactivity, it will be a very long time before it is possible for anyone to live at the site of the nuclear reactor again.

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SUSTAINABLE ENERGY

To prevent further depletion of fossil fuel stocks, sustainable energy is being used more and more often. **Sustainable energy** is energy that does not cause environmental pollution and does not use up the energy source. It is therefore also known as renewable energy. Examples of sustainable energy are energy from biofuels (biomass), wind power, solar power and hydroelectric power.

▼ **Fig. 18** Sources of sustainable energy in the Netherlands (2014).



Sustainable energy that is generated in the Netherlands comes mainly from biomass (see figure 18). **Biomass** consists of energy-rich organic substances such as wood, organic waste, manure and vegetable oils. Biomass can be used as fuel. Carbon dioxide is released during its combustion, but the plants absorbed it from the air as they grew in the first place. The amount of carbon dioxide in the air does not therefore increase.

Some plants are grown especially for the production of **biofuels**. In Brazil, for example, sugar cane is grown for the production of alcohol; car engines can be made modified to run on alcohol. Oil can also be obtained from sunflowers, oilseed rape and oil palms, for example. This oil can be used to produce **biodiesel** for cars.

These first-generation biofuels are made from food crops. A lot of agricultural land is needed for growing the crops for biofuel. This means that there is less land left for growing food. Many people therefore think that growing plants for biofuel is not sustainable. To tackle this disadvantage, second-generation biofuels are being developed. These are made from waste wood and agricultural waste such as straw (stems) and chaff (hard protective layers of corn grains), and also from e.g. used frying fat.

▼ Fig. 19

Algae are grown as well nowadays specifically for producing biofuels. Less land is needed for growing algae than for growing plants (see figure 19).

Biodiesel from algae

Algae are seen as the new source of biodiesel. Algae can grow on small surfaces. A Dutch company cultivates large quantities of algae in a kind of pond. Their growth is encouraged by adding extra carbon dioxide. After harvesting, the algae are pressed. This yields vegetable oil. This oil can be used in a bio-power station or turned into biodiesel.



▼ Fig. 20 Skyline pollution by wind turbines.



Wind turbines convert wind energy into electrical energy. The electricity generated goes to the electricity grid, so that power stations need to use fewer fossil fuels. Using wind energy is nothing new; in the past, mills and sailing boats also used the wind as an energy source. But wind turbines have disadvantages too. Many people do not like seeing wind turbines in the countryside. This is called **skyline pollution** (see figure 20). This is why wind farms are now being developed in the North Sea.

We have an endless supply of solar power. The energy from the sun can be used directly. Solar energy is used for solar boilers and solar panels, for instance. In **solar boilers**, water is heated by the sun and can then be used for showering or washing. In **solar panels**, electricity is generated by sunlight (see figure 21). Solar panels keep getting cheaper and more efficient. In the future they will therefore be able to generate enough energy on cloudy days as well.

► Fig. 21 Solar power.



1 a solar boiler



2 solar panels

Water power was used in the past as well, for example for sawing wood and grinding grain (see figure 22). Nowadays large dams are built in rivers for generating electricity. When a dam is built, an artificial lake is created, which has a massive impact on the environment (see figure 23). The Netherlands is too flat for building large dams. Even so, small dams have been built in the Maas and Rhine, but these do not generate much energy.

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► **Fig. 22** A water mill.



▼ **Fig. 23**

Environmental changes due to giant dam

The Three Gorges Dam in the Yangtze river in China is the largest dam in the world. The hydroelectric power station produces nearly as much electricity as is used in the whole of the Netherlands. But the dam has negative consequences as well. A large area was flooded when the dam was built and more than a million people had to move. Special and endangered animal species such as the Yangtze dolphin are threatened with extinction because the dam is blocking their migration routes.



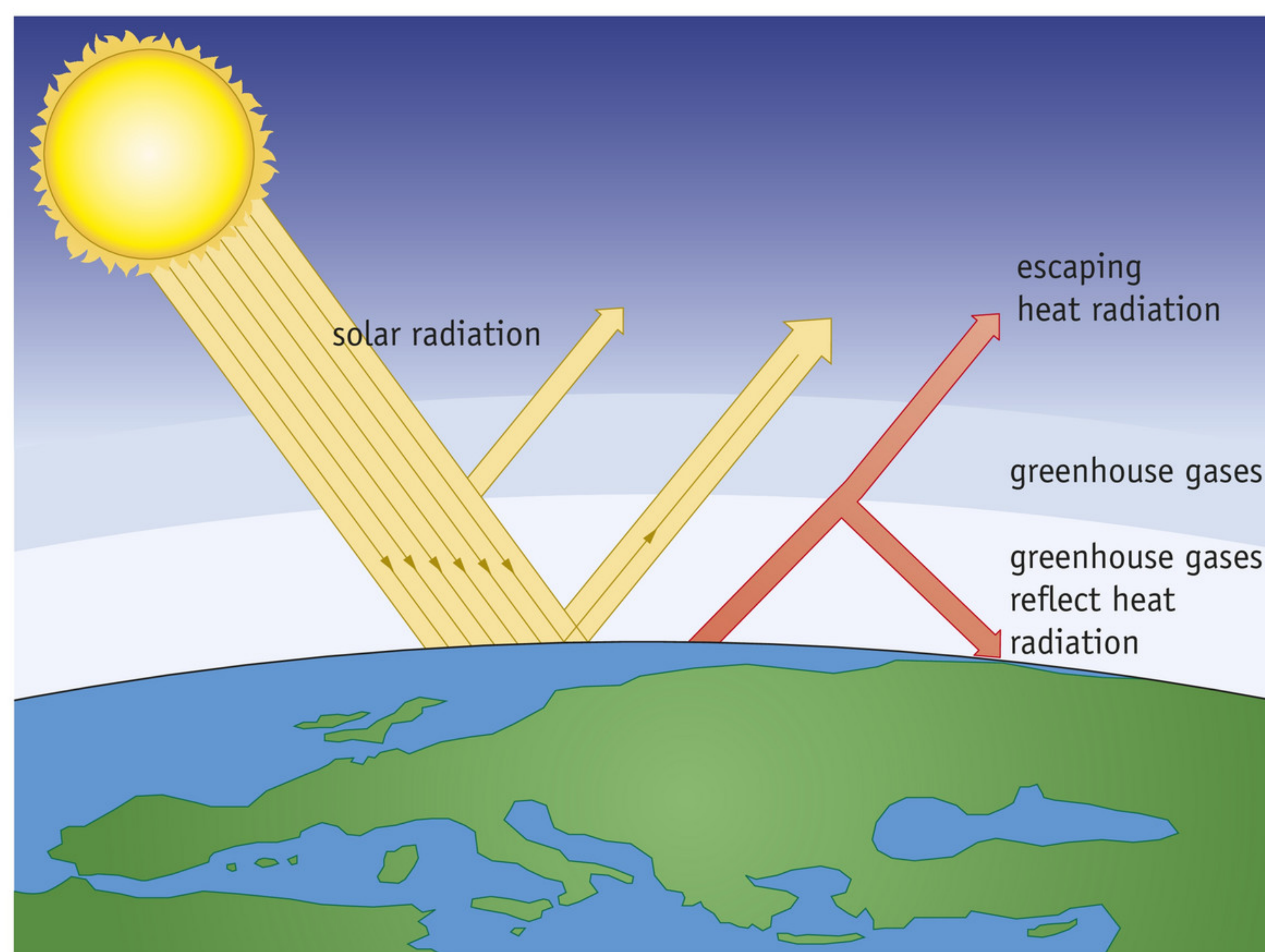
3 The greenhouse effect

The climate on Earth is largely determined by its **atmosphere**. The atmosphere is the layer of air around the Earth. It is a mixture of different gases. The gases in the atmosphere allow some of the solar radiation to get through to the Earth's surface. The rest is reflected.

Part of the solar radiation is converted into heat at the Earth's surface. The Earth also radiates heat away again. Certain gases in the atmosphere keep in some of the Earth's **heat radiation** (see figure 24). This keeps the Earth warmer.

The way that these gases trap the heat radiated by the Earth can be compared to a greenhouse (a glasshouse for growing plants). A greenhouse also traps the incoming heat. This is why the way these gases trap the heat radiated by the Earth is called the **greenhouse effect**. The gases in the atmosphere that cause the greenhouse effect are called **greenhouse gases**. **Water vapour** and **carbon dioxide** are the most important greenhouse gases. Because of the greenhouse effect, the average temperature on Earth is 15°C. Without greenhouse gases, the average temperature on Earth would be -18°C and there would probably be no life on the planet.

► **Fig. 24** The natural greenhouse effect.



THE ENHANCED GREENHOUSE EFFECT

Over the past hundred years, the average temperature on Earth has risen by about 0.8°C. The average temperature in the Netherlands has risen even more. According to most researchers, the rise in temperature is caused by the fact that humans are releasing more and more greenhouse gases into the atmosphere. As a result, the atmosphere traps more of the heat radiated by the Earth. This makes the temperature rise.

People have used more and more fossil fuels over the past hundred years. Combustion of these fuels releases carbon dioxide. The greenhouse effect is enhanced in particular by the increased levels of carbon dioxide in the air, but other factors play a role as well (see figure 25).

WB EXERCISES 13 TO 15, PAGE 88

▼ Fig. 25

Flatulence enhances the greenhouse effect

Flatulent sheep and cows contribute to the greenhouse effect. A lot of methane is released when the animals break wind. Together with carbon dioxide, this enhances the greenhouse effect. The gas is produced in the stomachs of ruminants such as cows and sheep. An average cow produces ninety kilograms of methane every year – as much greenhouse effect as a hundred and twenty litres of petrol.

Possibilities for reducing methane production are now being studied. Tests with genetically modified sheep have already proved that they release much less methane. Changes to the grassland could lead to less methane production as well.



CLIMATE CHANGE

We do not yet know everything about the consequences of the enhanced greenhouse effect. It is obvious that climate change could happen, though.

Climate change means that the weather type changes for a period lasting several years. One example of such a change is the rise of the average global temperatures on Earth, known as global warming.

The rise in temperature means that the seas and oceans are getting warmer as well. Water that gets warmer expands and takes up more space, making **sea levels** rise. Low-lying areas can get flooded because of rising sea levels. Ice melting in the Antarctic and melting from glaciers will also make sea levels rise (see figure 26). The melting ice ends up in the sea. The ice at the North Pole is also melting, but this is not having much impact on the sea level.

► Fig. 26 A glacier.

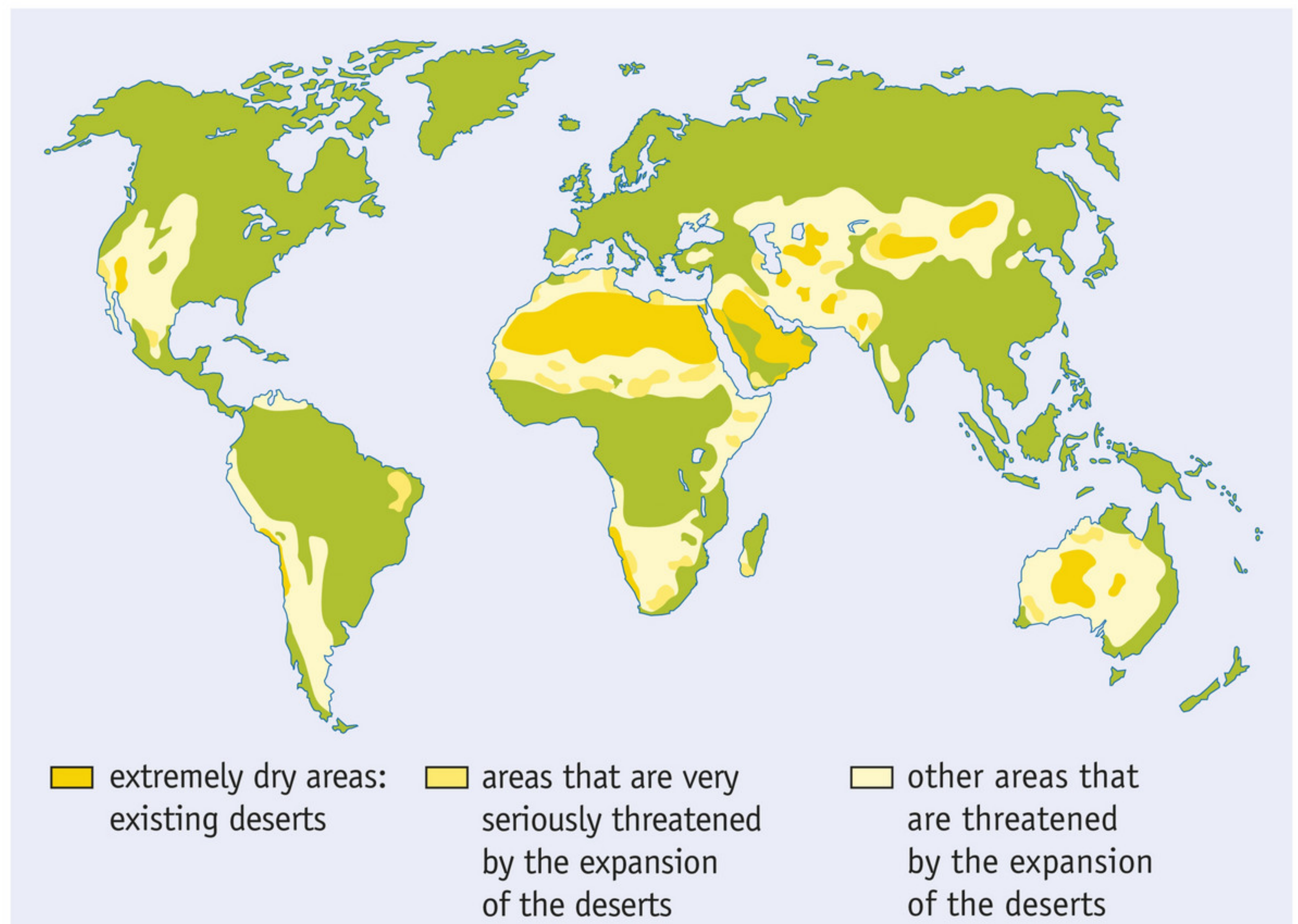


In certain areas, higher temperatures lead to drought, causing deserts to get larger (see figure 27).

Some researchers think food supplies will be threatened because agriculture will become impossible in large areas of the world. Others believe that the enhanced greenhouse effect may in fact be favourable for agriculture. Food crops will grow better when temperatures are higher. These crops will therefore produce more food. Moreover, parts of the world that are too cold now could become suitable for agriculture thanks to the higher global temperatures.

WB EXERCISES 16 AND 17, PAGE 89

► **Fig. 27**



▼ **Fig. 28** It is expected that the black grouse will vanish from the Netherlands as a result of climate change.

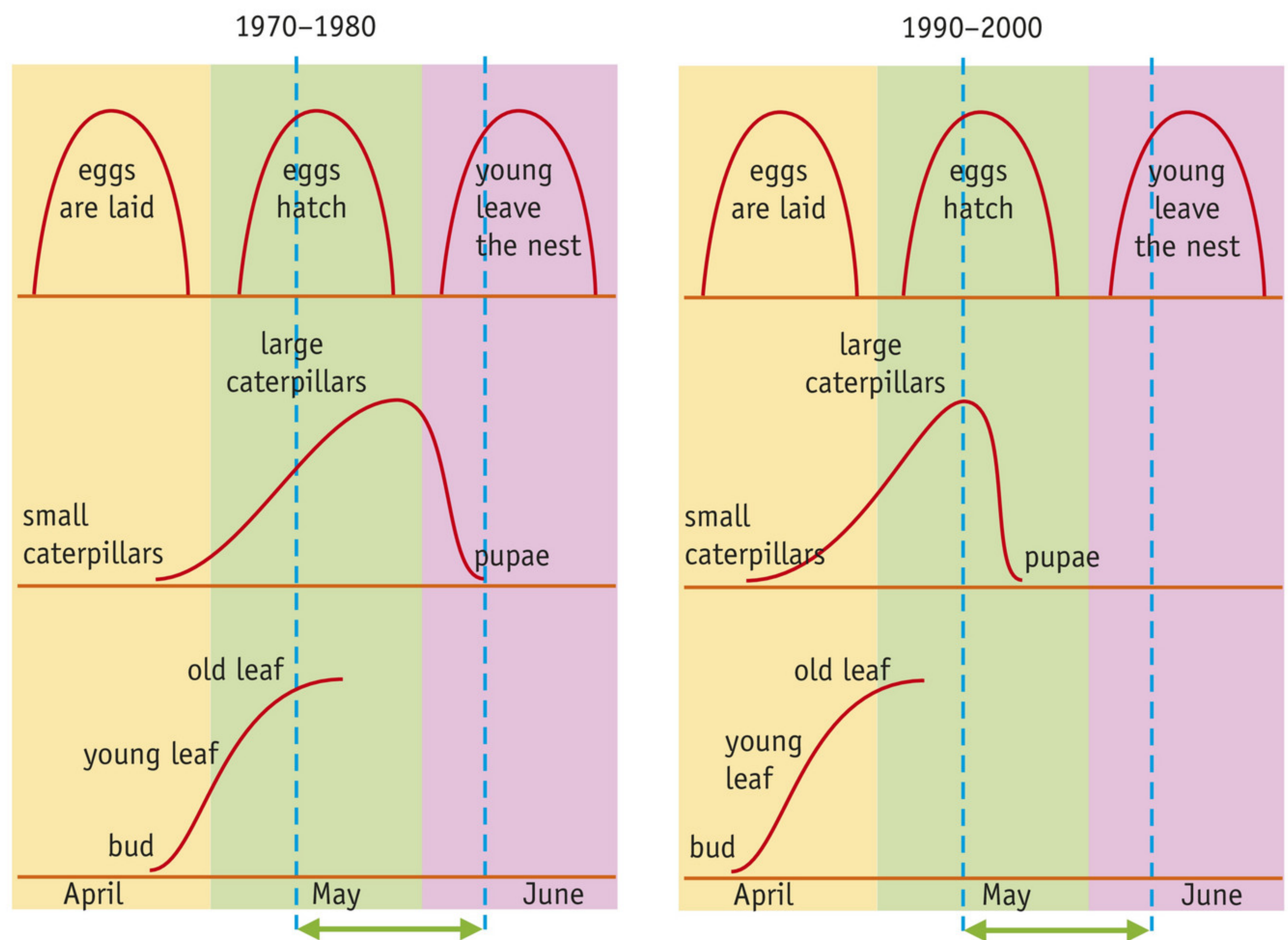


CHANGES IN NATURE

The consequences of climate change are already noticeable in nature. There are plant and animal species in the Netherlands now that used to live only in more southern areas such as in Belgium and France. Other species have become rarer or have disappeared altogether (see figure 28).

Because the winters are less severe and springs have become warmer, the annual rhythm of many species has changed. Trees are getting leaves earlier in the year and many plants are flowering earlier as well. This has serious consequences for some food chains. Great tits like to feed their young with winter moth caterpillars. These caterpillars eat oak leaves. As oaks are getting their leaves earlier in the year, winter moth caterpillars are also appearing earlier. But the annual rhythm of the great tits has not changed. In the period when the great tits' eggs have hatched and their young need to be fed, there are not enough caterpillars left (see figure 29).

▼ **Fig. 29** Climate change disrupts the food chain oak – caterpillar – great tit.



↔ = period when the birds feed their young

HEALTH CONSEQUENCES

Because of global warming, the number of warm days in the Netherlands is increasing. Numbers of deaths in hotter weather are going up. In a heatwave in August 2003, an estimated five hundred more people died that month than in a normal August. About two hundred of these extra deaths were caused by smog during the heat wave (see also basics 4).

Some diseases may also occur more often due to climate change. One example is Lyme disease, which is caused by a bacterium transmitted by ticks (see figure 30). Over the period from 2007 to 2013, the number of ticks caught more than doubled. Ticks spread in warm and humid weather in particular. Lyme disease is therefore sensitive to climate change.

WB EXERCISES 18 TO 20, PAGE 90

► **Fig. 30** A tick.



1 a tick sticks its head into the skin and sucks blood

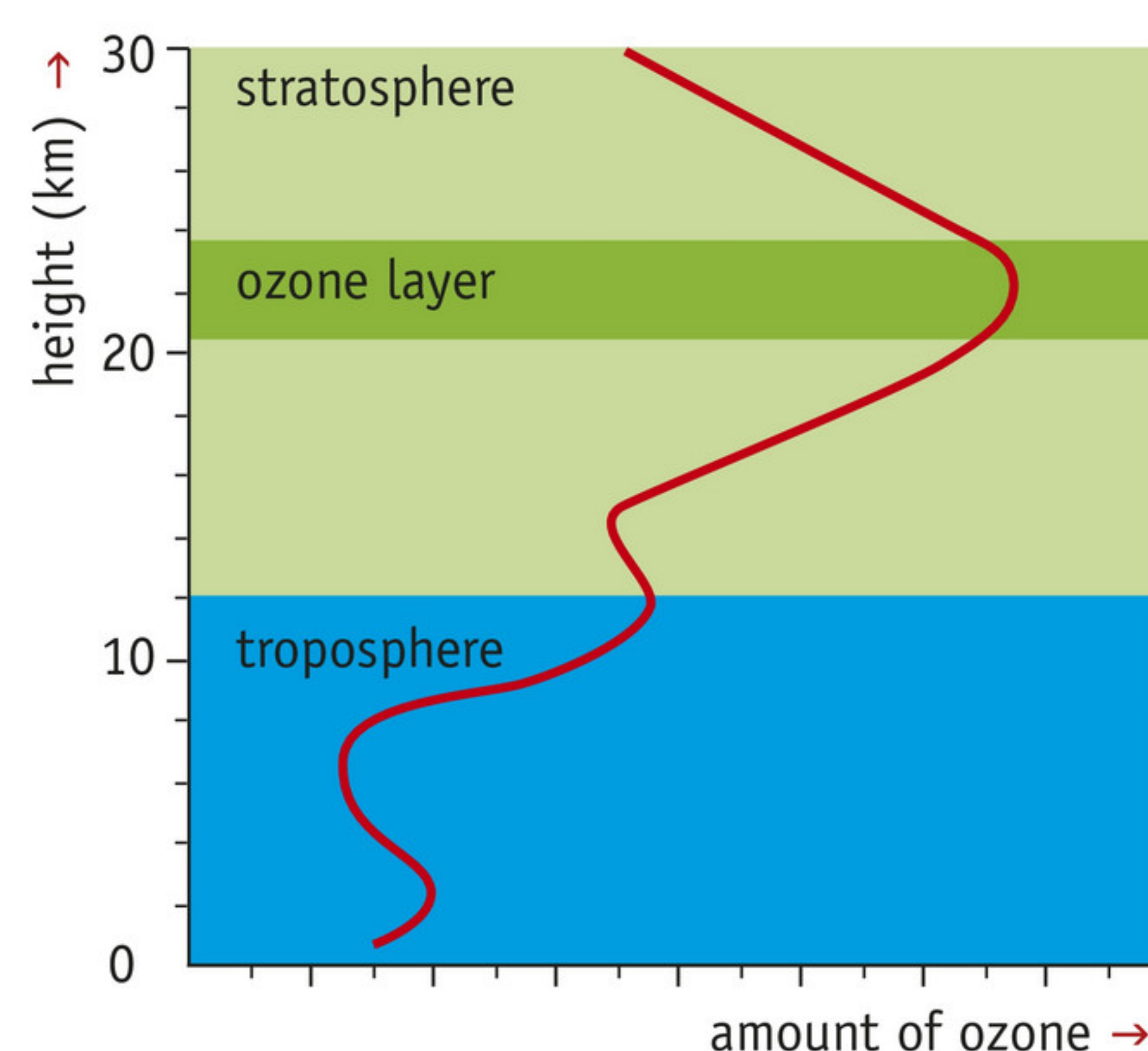


2 after a few days, a characteristic red rash appears around the location of the tick bite

4 Clean air

The atmosphere is made up of several different layers. The layer up to a height of twelve kilometres is called the **troposphere** and the layer between twelve and fifty kilometres up is called the **stratosphere**. Both layers contain a certain amount of **ozone** (see figure 31).

► **Fig. 31** Ozone in the troposphere and stratosphere.



Ozone is a gas that is formed from oxygen under the influence of ultraviolet light from the sun. This happens in a certain layer of the stratosphere in particular, known as the **ozone layer**.

The ozone layer blocks a large proportion of **ultraviolet radiation** from the sun. Organisms on the Earth are thus protected against this radiation. This is important because large amounts of ultraviolet radiation are harmful to organisms. Ultraviolet radiation can cause skin cancer in humans, for instance. Due to the use of substances such as CFCs that damage the ozone layer, it became thinner in the period from 1980 to 2010. **CFC** is short for chlorofluorocarbon. These substances were widely used as propellants in aerosol sprays and as refrigerants in fridges and freezers (see figure 32). During the period when the ozone layer became thinner, the number of cases of skin cancer increased by about 10%. Above the South Pole, the ozone layer became so thin that people referred to it as the **ozone hole**. Worldwide, substances that damage the ozone layer are used much less now. The thickness of the ozone layer has stayed the same or even increased slightly since then.

► **Fig. 32** The cooling element of a fridge.



SMOG

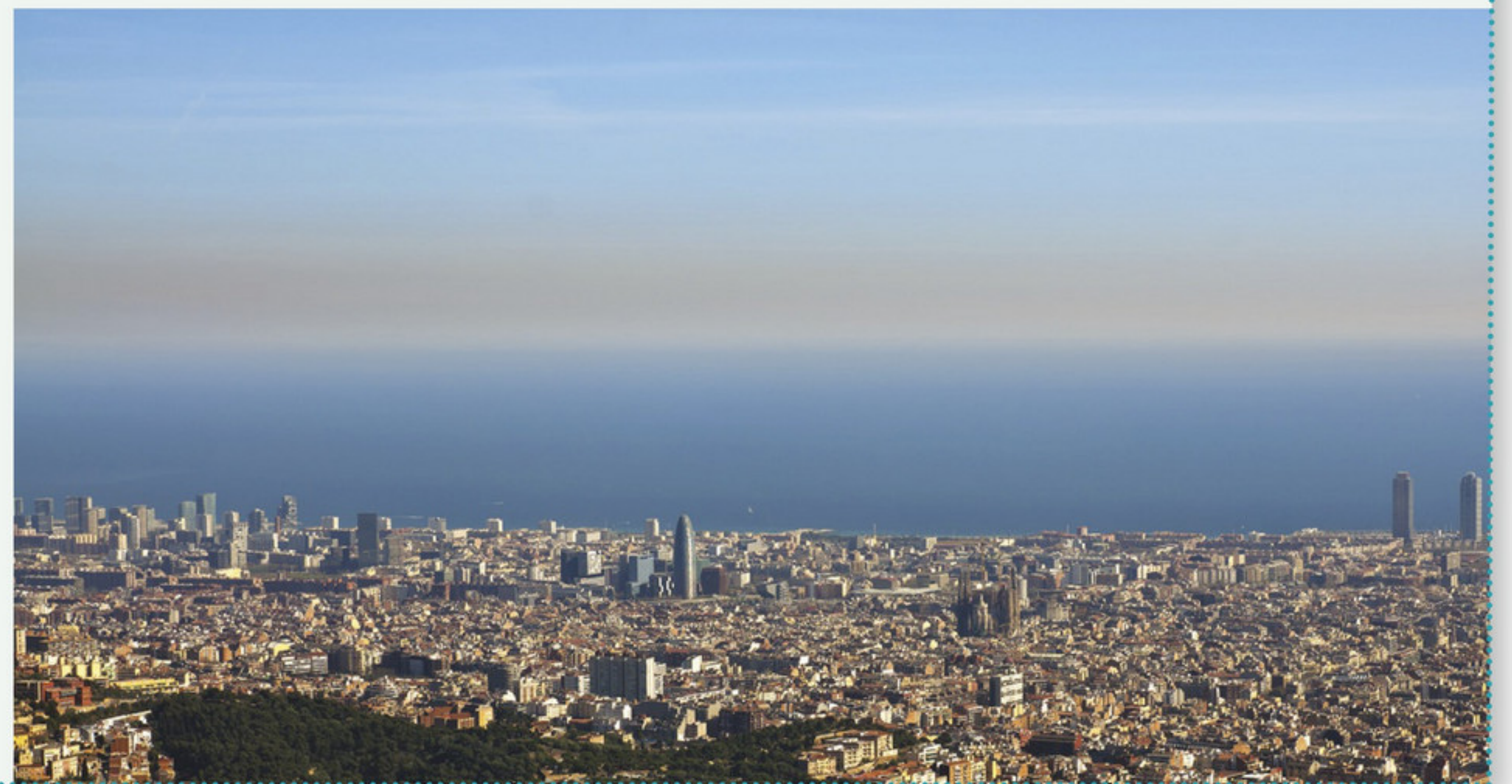
Smog is a kind of fog that is heavily polluted by smoke and exhaust gases. The word smog is a contraction of the words *smoke* and *fog*. In nearly all big cities there is a smog problem from time to time. In particular, smog affects people with lung conditions such as asthma and COPD. Dense smog can even be fatal (see figure 33).

There are two types of smog: summer smog and winter smog. Summer smog consists of fog containing ozone, particulate matter and exhaust gases, among other things. You can tell this kind of smog by its brown colour. Winter smog consists mainly of particulate matter and gases that are released by the combustion of coal and oil. Winter smog has a grey colour.

▼ Fig. 33

Smog claims thousands of lives in Spanish cities

The air pollution in Spanish cities is getting worse and worse. In nearly all the major cities in Spain, levels of air pollution are higher than allowed by Spanish law. This is mostly caused by traffic. Air pollution is a serious threat to public health. More people are suffering from allergies, breathing problems and cardiovascular disease. In Barcelona alone, air pollution claims three thousand five hundred lives every year.



▼ Fig. 34 Exhaust gases from cars generate particulate matter.



SUMMER SMOG

Many cities suffer from **summer smog** during the summer. When the weather is hot, chemical reactions take place between the combustion products of fossil fuels, triggered by sunlight. This causes summer smog. The ozone that these reactions releases irritates the mucous membranes of the airways in many people.

Some of the ozone from summer smog collects in the upper layer of the troposphere and gives it a brownish look. The ozone acts as a greenhouse gas there, enhancing the greenhouse effect. Particularly in the northern hemisphere (the area to the north of the equator), ozone can cause extra rises in temperature.

PARTICULATE MATTER

Particulate matter consists of particles of various origins that are floating in the air. These particles are grouped into three categories: particles with diameters between 10 and 2.5 micrometres, those with diameters between 2.5 and 0.1 micrometre, and those with diameters less than 0.1 micrometre. A micrometre is one thousandth of a millimetre.

55% of all particulate matter is of natural origin (for example from sand and sea salt). The other 45% ends up in the air as a result of human activity. Emissions generated by humans largely come from transport and industry. Examples of these particles are the dust residues from brake discs, rubber particles from tyres and exhaust gases (see figure 34). Wood-burning stoves in houses, barbecues and the large amounts of fireworks let off during New Year celebrations also create particulate matter.

The particulate matter produced by human activities is particularly harmful to our health. Such particles have been linked to cardiovascular disease and lung conditions such as bronchitis. They can make the symptoms of asthma worse as well. Smaller particles are more harmful because they can get deeper into the airways and lungs. These small particles cause inflammation in the lungs, making it more difficult for the body to absorb oxygen. In the Netherlands and Belgium, several thousand people die prematurely every year because of exposure to particulate matter.

ACIDIFICATION

When fossil fuels are burned, gases are produced that can cause acidification of the environment. **Acidification**, often called acid rain, can cause diseases in plants and make them lose their leaves or needles (see figure 35).

► **Fig. 35** Forest affected by acid rain.



REDUCING AIR POLLUTION

In the 1990s, the Dutch government introduced measures to reduce emissions of pollutants from transport, industry and livestock farming. Car exhausts, for example, were fitted with catalytic converters to neutralise the gases that cause acid rain. Diesel vehicles were fitted with soot filters to reduce the amount of particulate matter emitted. In addition, cleaner fuels and lower speed limits reduced air pollution.

In the industrial sector, filters were placed in chimneys and flues. In poultry farming, particulate matter is removed from the air using air scrubbers and other measures. This involves purifying the outgoing air of particulate matter using water. As a result of these measures, levels of particulate matter have been reduced by 25%.

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5 Waste

▼ **Fig. 36** Waste from humans.



Due to the population growth and the changes in our lifestyles, people are now producing much more waste. Other names for waste are rubbish and refuse.

Maybe you think of **waste** just as the household refuse that you put in a waste bin or in a rubbish bag (see figure 36). But that is only part of the waste that we produce. It is not only people that produce waste: plants and animals do too. Waste from plants consists of fallen leaves or fallen trees, for example (see figure 37.1). Waste from animals consists of their droppings or the dead animals themselves, for example (see figure 37.2).

▼ **Fig. 37**



1 waste from plants



2 a dead animal is waste too

▼ **Fig. 38** Biodegradable waste.



Decomposers (bacteria and fungi) break down the waste from plants and animals. This is called **biodegradation**. In other words, waste from plants and animals is **biodegradable** (see figure 38).

People make products from parts of plants or animals. Waste from these products is biodegradable as well. Examples of this kind of waste are bread crusts and paper.

For centuries now, people have been making products from glass, metal and stone. Waste from these products is not biodegradable. This is called **non-biodegradable waste** (see figure 39).

Nowadays, a lot of products are also made from synthetic materials such as **plastics**, nylon or polystyrene (see figure 40). Synthetic materials are almost never biodegradable. Products made from synthetic materials persist in the environment for many years. Some plastics crumble into smaller pieces after a certain amount of time. These smaller pieces are often harmful too (see figure 41).

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▼ **Fig. 39** Non-biodegradable waste.



▼ **Fig. 40** Products made from plastics.



▼ **Fig. 41**

Plastic soup

A huge rubbish dump of plastic waste is floating on the Pacific Ocean. The area is as large as the total land area of France, Spain and Portugal combined. The plastic in this rubbish dump is often invisible to the human eye. This is because it gets fragmented into smaller and smaller pieces under the influence of sunlight. A sort of plastic soup has been created this way. There are areas full of plastic rubbish in the Atlantic Ocean and Indian Ocean as well.

These plastic soups threaten all life in the oceans. Insects such as the sea skater lay vast numbers of eggs on the small pieces of plastic. These eggs are eaten by crabs and by other animals, which ingest the small pieces of plastic as well. This is how the plastic particles get into the food chain. In the end the plastic goes up through the food chain into the bodies of predatory fish, birds and seals. The consequences of

this vary from hormonal imbalance to poisoning. Via shellfish and fish, the plastic can also get into the bodies of humans in the end.



DOMESTIC WASTE

Waste from households is called **domestic waste**. In the Netherlands, about nine billion kilograms of domestic waste is collected annually. This waste consists of **household waste** and **bulky waste** (see figure 42). Figure 43 shows you what the household waste is made up of.

In addition, the commercial sector produces roughly another 45 billion kilograms of waste per year. Examples of this are scrap cars, old tyres, demolition waste and agricultural waste. All of this waste has to be collected and processed.

▼ Fig. 42 Bulky waste items.



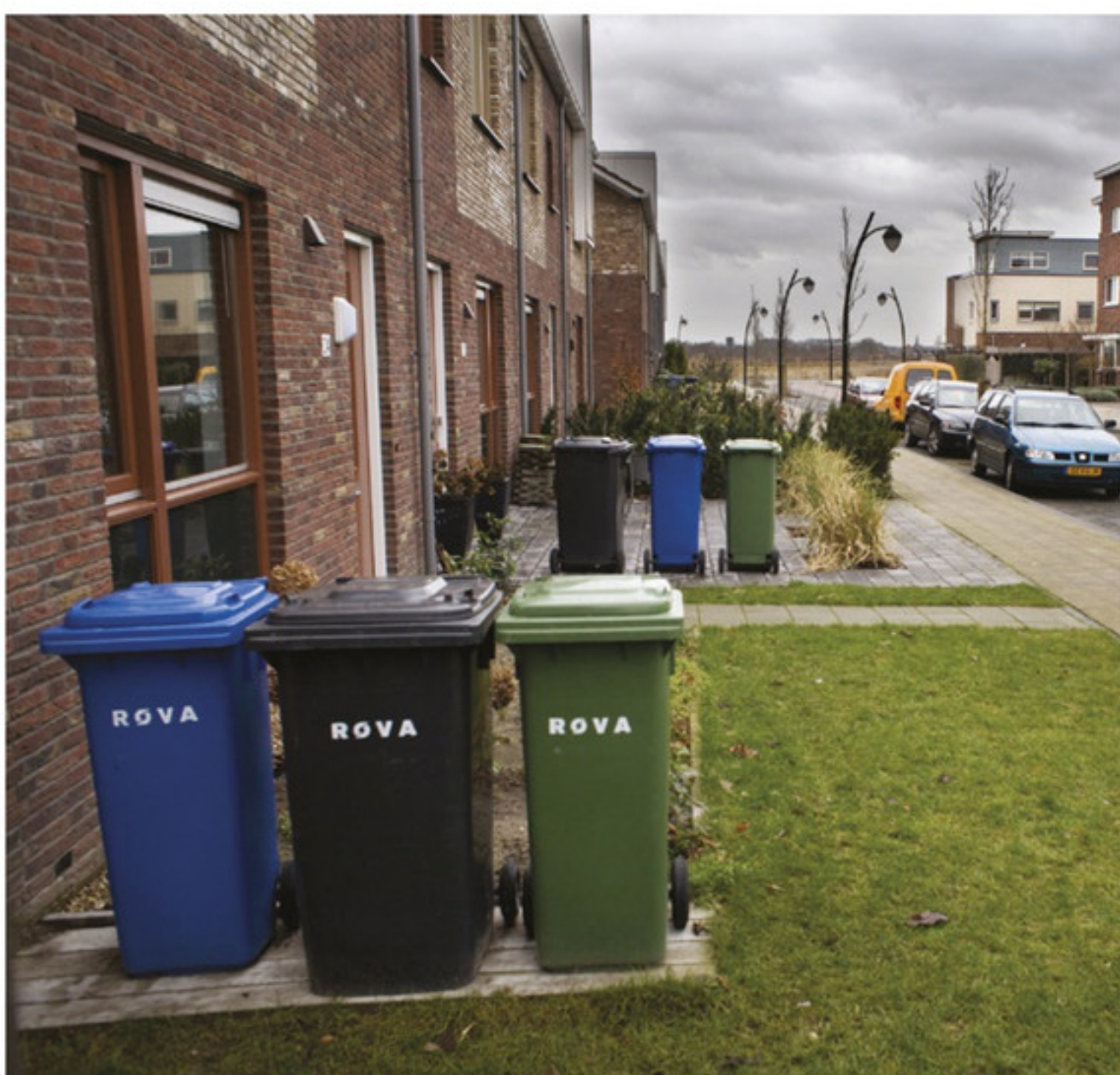
▼ Fig. 43 The composition of household waste.



Legend:

- | | |
|--|-------------|
| organic waste | textiles |
| paper and cardboard | metals |
| plastics and other synthetic materials | other waste |
| glass | |

▼ Fig. 44 Waste bins.



In practically every municipality in the Netherlands, different kinds of household refuse are collected separately. Many people have **waste bins** at home (see figure 44). One of the bins is for organic waste (food and garden waste). This **organic waste bin** (called GFT in the Netherlands) is often green. Another bin is for waste that cannot be collected separately. In some municipalities you have to use rubbish bags for this **residual waste**. In many municipalities, paper, glass, plastic, textiles and small-scale chemical waste are also collected separately. Supermarkets or shopping centres often have special bins for these types of waste.

▼ Fig. 45



1 bottle bank



2 paper container

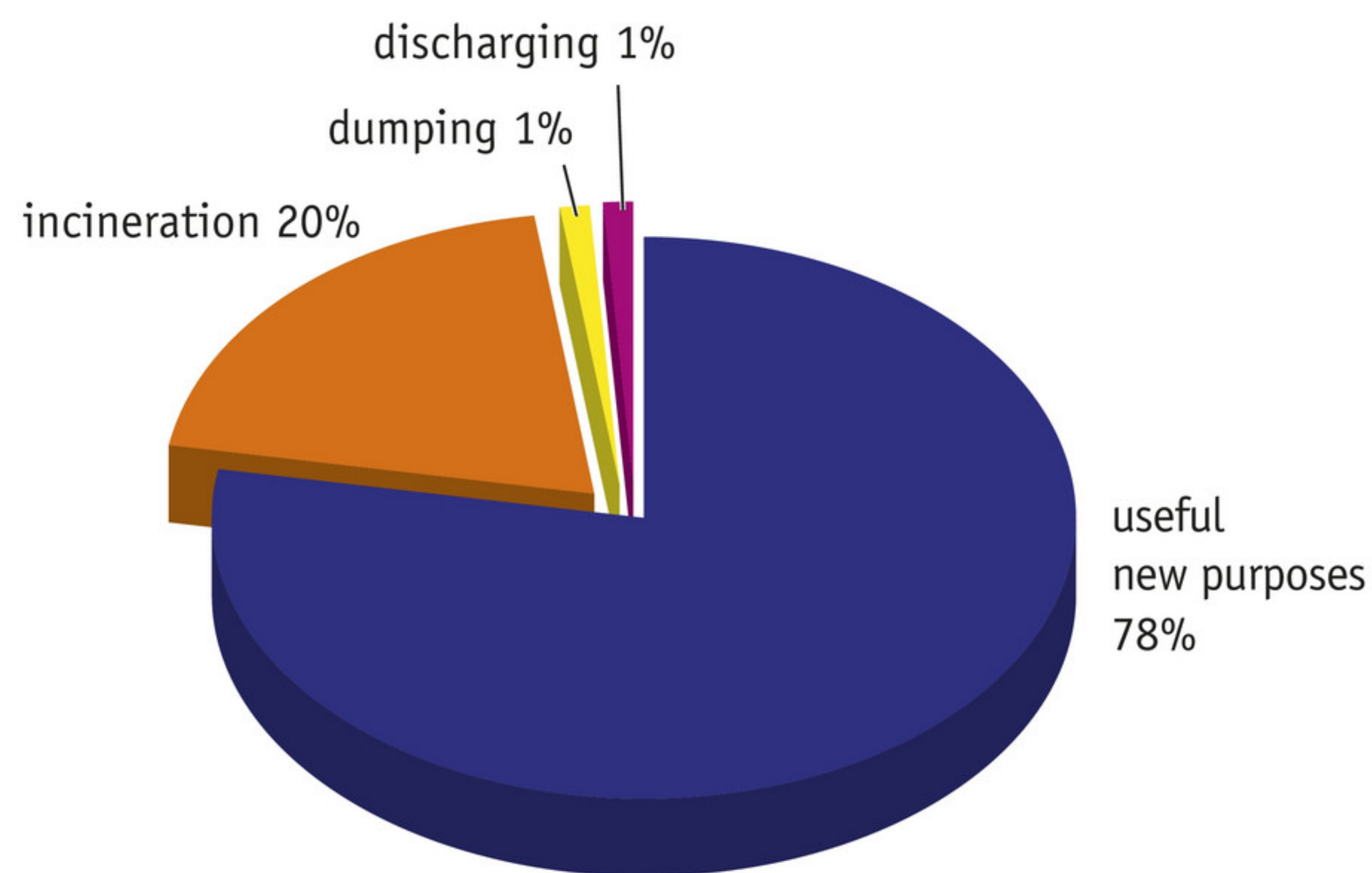


3 textile container

WASTE TREATMENT

If the waste is collected separately, it can then be processed in three different ways. It can be incinerated (burned), dumped, or reused in some useful way. Recycling, reuse and composting are ways of processing waste usefully. In 2010, about 78% of all waste in the Netherlands was used for new purposes, 20% was incinerated, 1% was discharged and 1% was dumped (see figure 46).

► Fig. 46 Separated waste processing in the Netherlands in 2010.



▼ Fig. 47 Returnable bottles are reused.



In the case of **reuse**, an object is used again, such as returnable bottles (see figure 47). In the case of **recycling**, waste products are used as **raw materials** for new products. Paper, glass, metals and clothing are mostly recycled. Cars and electrical devices (such as televisions and computers) are disassembled first. Some parts can be used again. The other parts are processed into raw materials for new products as far as possible. This avoids toxic substances ending up in the environment.

▼ Fig. 48 Compost.



▼ Fig. 49 Incinerator.



In the case of **composting**, food and garden waste is degraded by decomposers (bacteria and fungi). You have learned that nutrients for plants are released in this process. Organic waste is thus converted into a kind of fertiliser containing a lot of nutrients for plants. This type of fertiliser is called **compost** (see figure 48). Composting is environmentally friendly because nutrients from organic waste are used for making plants grow. Some 20% of all household waste is incinerated. **Incineration** is done in large incinerators (see figure 49). The incineration process releases **heat**. A large proportion of this heat is used to generate electricity and to heat houses and greenhouses.

A small fraction of the waste (about 1%) is dumped on landfill sites. **Dumping** is the easiest and cheapest method of waste disposal. But it does have a number of drawbacks. A landfill site can smell very bad and often attracts a lot of vermin.

Many municipalities have a **waste collection point** (see figure 50). Sometimes this is also referred to as the recycling centre or the civic amenity site. Residents of the municipality can take waste to this collection point themselves – items such as garden refuse, rubble from renovation work, scrap metal and old furniture. It has a depot for small-scale chemical waste as well. **Small-scale chemical waste** (or KCA in Dutch) is all chemical waste from households (see figure 51). Small-scale chemical waste can also be returned to the shops or companies where you bought the products. For example: old medicines can be returned to pharmacies and empty batteries can be returned to camera shops.

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▼ Fig. 50 A waste collection point.



▼ Fig. 51 Small-scale chemical waste.



6 Food production

You have learned that the world population is still growing. All those people need to eat. Food for humans comes from agriculture. **Agriculture** includes various activities that change the natural environment, making it suitable for producing plants and animals that are then consumed or used by people.

There are three types of agriculture: **arable farming**, **livestock farming** and **horticulture** (see figure 52). Plants that are grown in arable farming and horticulture are called **food crops**. Animals that are kept in livestock farming are called **farm animals**. People have been trying for centuries to maximise the yields of food crops and farm animals. For food crops, this can be done by fertilising and processing the soil and by protecting the crops against diseases and pests. For farm animals, it can be done through special feed for the animals and by protecting them against disease. Yields can also be improved by breeding and cross-breeding or by using modern techniques from biotechnology.

▼ **Fig. 52** Three types of agriculture.



1 arable farming



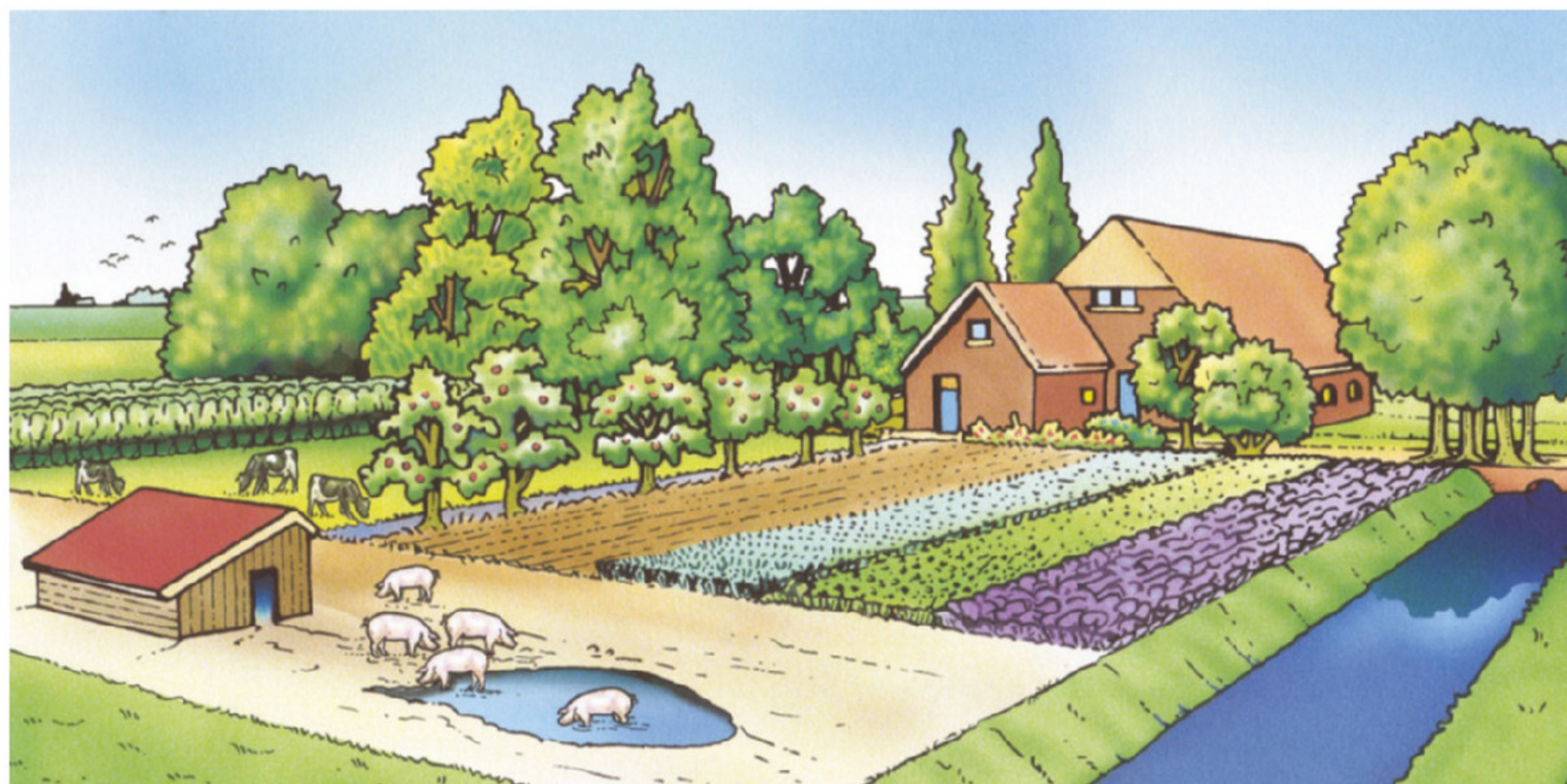
2 livestock farming



3 horticulture

Agriculture in the Netherlands has changed a lot in the past sixty years. Until 1950, most farms were **mixed farms**. The farmers practised both arable farming and livestock farming. In most cases, they grew vegetables as well (see figure 53). Nowadays, most farms are specialised arable farms, livestock farms or horticultural farms.

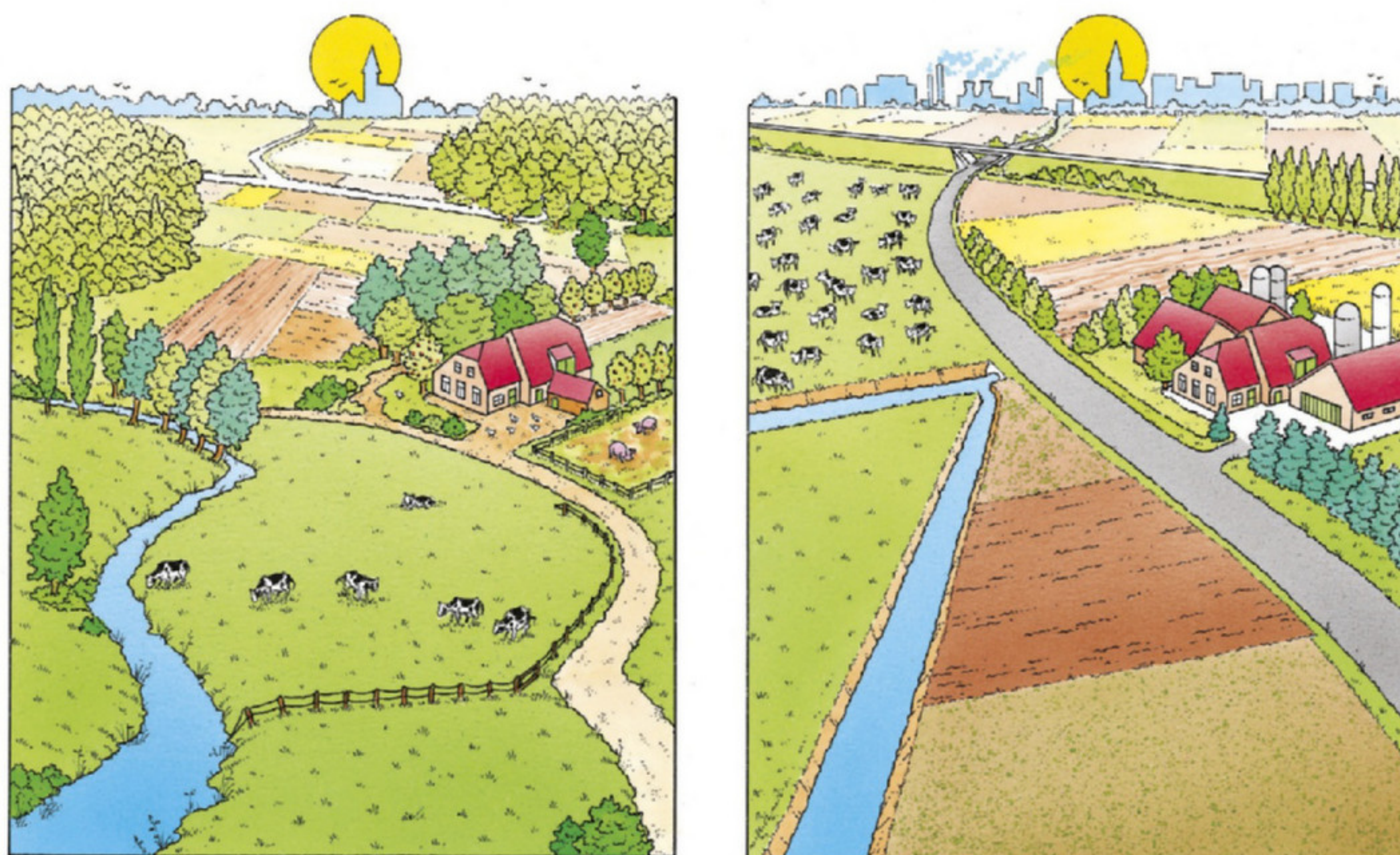
► **Fig. 53** Agriculture on a mixed farm.



ARABLE FARMING

Arable farms are often large farms with a lot of land. Land consolidation over time has led to small fields being joined together to create larger ones. This has changed the landscape a great deal (see figure 54).

► **Fig. 54** Changes in the landscape due to land consolidation.



1 landscape in 1950

2 landscape in 2014

▼ **Fig. 55** Monoculture.



▼ **Fig. 56** In monocultures, large machines can be used.



Most of the time, only a single type of crop is grown on those large fields, for example potatoes, wheat or sugar beets. This is called a **monoculture** (see figure 55).

Monocultures have great advantages for the farmers. They can use larger machines for working the soil and for harvesting (see figure 56). This is fast and easy. Crops can be grown more cheaply as monocultures. A field is highly productive.

But monocultures have disadvantages too. In monocultures, there is a lot of food for insects. There is therefore a higher risk of insect pests. The plants in a monoculture also grow very close to each other. As a result, pathogens can spread easily among the plants.

Arable farmers often fight insects and pathogens with **chemical pesticides** (toxins). Many chemical pesticides also kill useful organisms such as earthworms in the soil.

Many fields in the Netherlands have ditches at the edges. The pesticides can get into the water in the ditches or end up in the groundwater. Drinking water in the Netherlands is largely pumped up from the ground. Chemical pesticides therefore threaten the quality of our drinking water.

Another disadvantage of monocultures is the rapid exhaustion of the soil. Fertilisers are added to put the minerals back into the soil. There are two types of fertilisers: organic fertilisers and chemical fertilisers. **Organic fertilisers** come from organisms. **Chemical fertilisers** are made artificially in laboratories or factories. Because it gives them more control over the types and quantities of minerals added to the soil, farmers often use chemical fertilisers for fertilising the land.

A proportion of the chemical fertilisers ends up in water in ditches and in the groundwater. This makes the water less suitable for drinking.

LIVESTOCK FARMING

Livestock farms in the Netherlands were originally grazing farms. Grazing farms are farms with cows, sheep, goats or horses. Many livestock farms have little land nowadays – pig farms and poultry farms in particular. This type of livestock farming is called **intensive livestock farming** and is also referred to as **industrial livestock production** or **factory farming**. Since the farms do not have much land, they do not grow their own feed. Instead, they buy it from feed companies. Some 70% of the raw materials for the production of feed comes from abroad (see figure 57).

▼ **Fig. 57** The import of raw materials for feed into the Netherlands.

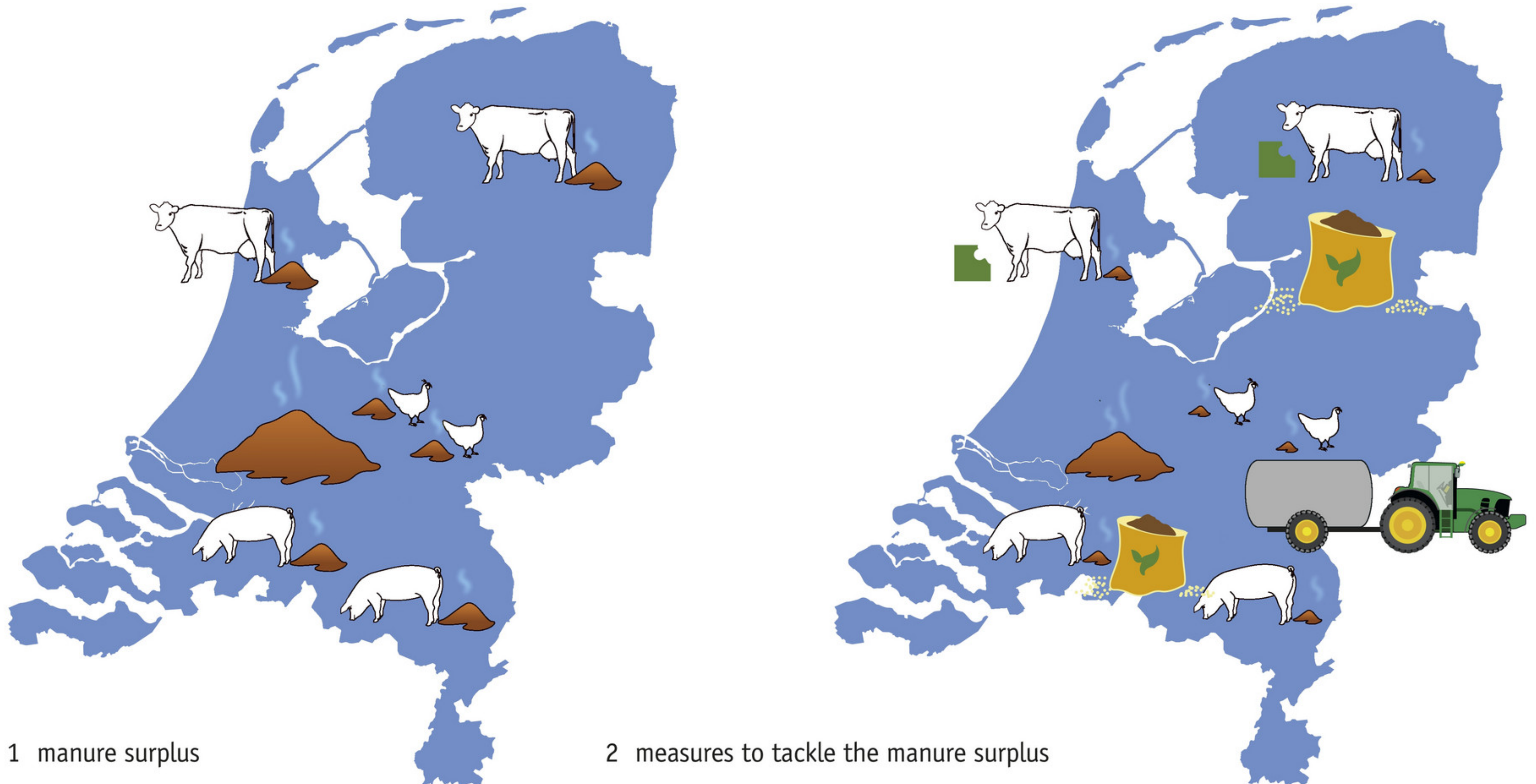


Factory farming has a number of advantages for livestock farmers. Feed concentrates let a livestock farmer keep large numbers of animals (see figure 58). Because they keep a very large number of animals, they can produce a great deal of meat, milk or eggs. But factory farming does have some drawbacks as well. Factory farming creates a **manure surplus** because the farm produces more manure than is needed for fertilising its land (see figure 59). Manure can pollute groundwater, surface water and drinking water (see figure 60). You will learn more about water and soil pollution in extra 8.

► **Fig. 58** Animals in factory farming.



▼ Fig. 59



1 manure surplus

Farmers use manure for fertilising their fields and pastures. The use of animal manure is legally restricted because too much manure is bad for the environment. The remaining manure is called the manure surplus.

2 measures to tackle the manure surplus

through feed

Animals get adjusted feed so that the manure will contain less phosphate.

through manure processing

The manure is processed into e.g. fertiliser.

through export

The manure is processed to make it suitable for export.

Source: Ministry of Agriculture, 2013.

▼ Fig. 60

Environmental technologist

Hello. My name is Peter Schipper. I'm a water quality researcher working at Alterra, one of the research institutes of Wageningen University. After I got my bachelor's in environmental technology, I started working at Grontmij, a large consulting firm where I started doing all sorts of studies on groundwater. It particularly fascinated me to see how rainwater reacts with different pollutants that

end up on and in the soil (fertilisers, pesticides, heavy metals). I am also fascinated by the way that these substances get into groundwater, surface water and drinking water. I have been working at Alterra since 2010. Our research projects are not limited to the Netherlands, but cover the whole world. We are particularly well-known for our knowledge of agriculture and nature.



HORTICULTURE

In the past, **horticultural farms** used to grow most crops outdoors (see figure 61). This is called **open-field horticulture**. Nowadays, many horticultural crops are grown in greenhouses. This is called **greenhouse horticulture** (see figure 62).

▼ **Fig. 61** Open-field horticulture.



▼ **Fig. 62** Greenhouse horticulture.



▼ **Fig. 63**



Greenhouse horticulture has great advantages for the farmers. In the greenhouses they can create favourable conditions for the plants' growth. They can therefore produce a lot of food in their greenhouses. Greenhouse horticulture has another advantage as well. Food crops can be grown all year round in greenhouses. As a result, a lot of vegetables can be bought all year round (see figure 63). For example, a horticulturalist can harvest lettuces in winter.

But greenhouse cultivation does have drawbacks as well. In summer, there is enough light and heat in the greenhouses for the plants to grow well. In the other seasons, bright lights are needed to create enough light in the greenhouses (see figure 64). These lights consume a lot of electricity. Burning natural gas for heating the greenhouses releases waste products, including carbon dioxide. Carbon dioxide enhances the greenhouse effect. Because lights and heating are used, ten times as much energy is needed on average for growing a kilogram of greenhouse vegetables as for growing a kilogram of vegetables in an open field. Pathogens can easily spread among crops in the greenhouses. Biological pest control is often used for fighting pathogens in greenhouse horticulture. In greenhouse horticulture, fewer chemical pesticides are used than in open-field horticulture. You will learn more about biological pest control further on in these basics.

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► **Fig. 64** Lighting in a greenhouse.



THE FISHING INDUSTRY

Some of our food products come from the **fishing industry**. The growth of the world population and more and more advanced fishing methods have made overfishing an issue. **Overfishing** means that too much fish is caught in a certain area. As a result, particular fish species disappear from this area. Because of overfishing, various fish species are threatened with extinction. This includes herring, eel, cod and most kinds of tuna.

Another drawback of fishery is the bycatch. The **bycatch** is the unintentional inclusion of unwanted kinds of fish in the catch. When a fisherman wants to catch herring, a lot of other kinds of fish also get into the nets. The bycatch is often discarded.

In addition to catching fish at sea, fish farming is getting more and more common as well. **Fish farming** is breeding fish in special tanks or cages. One advantage of fish farming is that it is cheaper than fishing in the wild. It can also prevent overfishing. There are fish farms in the Netherlands as well. Catfish, eel, tilapia, turbot and trout are bred, for example.

INSECTS

In addition to meat and fish, more and more people in the Netherlands are eating insects as well. Insects are a good source of protein, for instance (see figure 65).

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▼ Fig. 65

Eating insects: sustainable and delicious

A bowlful of grasshoppers provides lots of healthy nutrients. On top of that, a dish like this is better for the environment than a steak. In all the continents except Europe and North America, people often eat insects. This can range from a packet of fried ants to a bowl of bee soup.

The Ministry of Agriculture, Nature and Food Quality is investing €1,000,000 in research by Wageningen University into using insects as food in the Netherlands. Insects are actually healthy and sustainable. Insects provide protein, iron and vitamins A, B2 and D, as well as other nutrients – much the same as pork, chicken and beef. The fat content is often lower, and the fats that they do contain are mostly unsaturated ones such as linoleic acid.

Much less agricultural land is needed for breeding insects and much less carbon dioxide is released. Insects need much less feed too. Three times more feed is needed for a kilogram of beef, for example, as for a

kilogram of edible insects. This also means that less manure is produced.

Researchers and insect companies are developing mixed products as well. For example, snacks of minced chicken mixed with mealworms. This may make it easier to convince people who have doubts about eating insects.



From: www.gezondheidnet.nl.

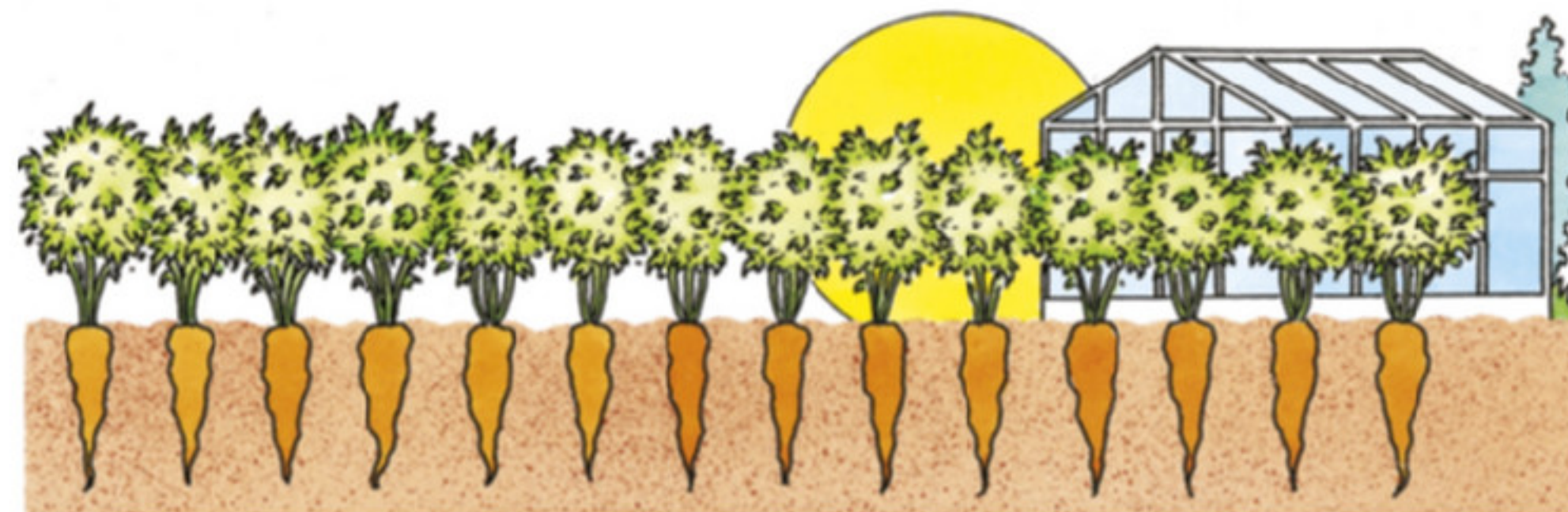
ORGANIC FARMING

Thanks to regular (intensive) farming methods, there is enough food in the Netherlands. Food is affordable too. You have learned that intensive farming has disadvantages for the environment and for farm animals. More and more people believe that the environment and animals should be treated better by agriculture.

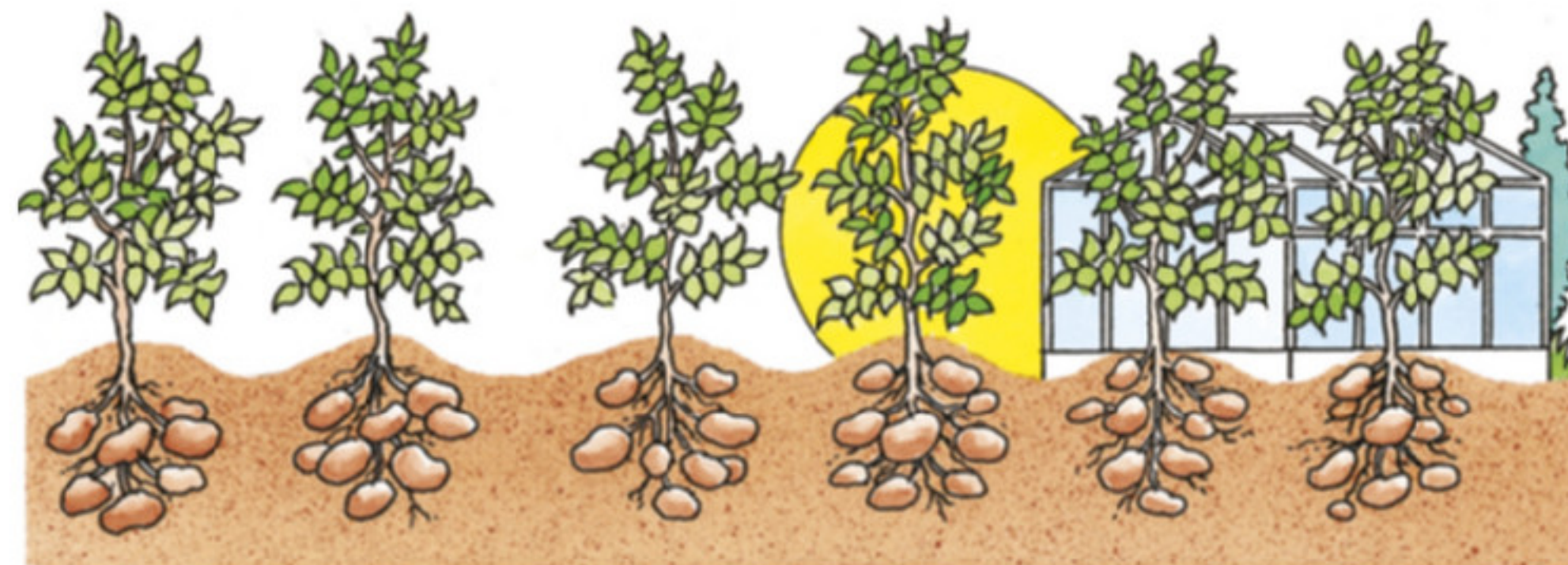
Organic farming tries to protect the environment while still producing enough food. Monocultures are avoided, for example, and crops are varied on smaller plots of land. This reduces the risk of insect pests. Crop diseases then spread less rapidly too. Furthermore, **crop rotation** is practised in organic farming. The same crop is never grown in the same field for two years in a row. You can see an example of crop rotation in figure 66. Pathogens usually cause disease in just one specific crop and stay in the soil for another one or two years after harvesting. The crop is harvested before the pathogens do any damage. The year after, a different crop is grown in the field. The text in figure 67 is taken from a folder and gives the key features of organic farming.

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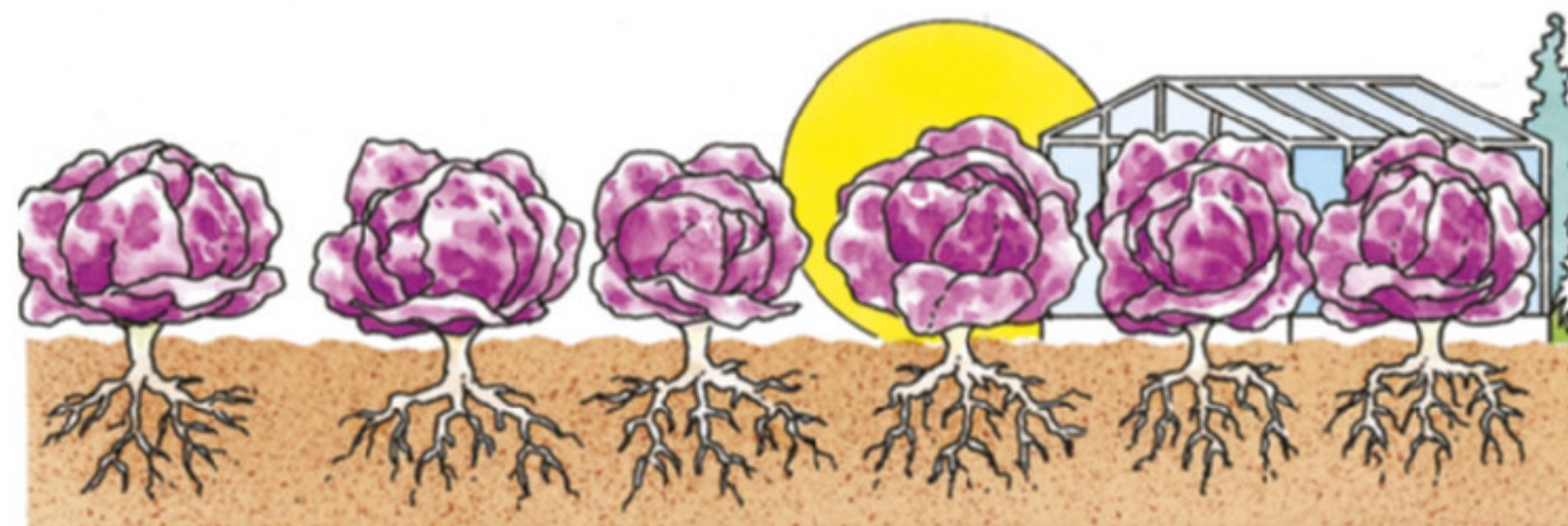
► Fig. 66 Crop rotation (schematically).



1st year: carrots



2nd year: potatoes



3rd year: red cabbage



4th year: carrots

▼ Fig. 67

ORGANIC FARMING

Organic farming methods:

- have a minimal impact on the environment;
- provide healthy (and tasty) products;
- are animal-friendly.

Organic arable farming and horticulture:

- do not use chemical fertilisers;
- use manure from organic livestock farming only;
- do not use more fertiliser than the plants can absorb;
- do not have monocultures;
- do not use chemical pesticides.

Protect food crops against disease and pests by:

- applying crop rotation (mostly in six-year cycles);

- growing different types of food crops on small pieces of land;
- controlling insect plagues using natural enemies.

Organic livestock farming:

- makes sure that there is more than enough space for the animals to run free (free-range animals);
- uses organically grown feed for the animals;
- pays attention to the well-being of the animals;
- only uses veterinary medicines when an animal is sick.

Organic products:

- do not contain residues of chemical pesticides;
- do not contain artificial aromas, colourings or flavourings;
- can be recognised by the European 'organic' label.



► Fig. 68 Products from organic farming.



7 Control of pests and diseases

▼ Fig. 69 Damage from insects.



Bacteria and fungi can cause diseases in food crops. Insects and other animals eat parts of food crops (see figure 69). When a lot of animals affect the food crops, this is called a **plague**. Disease and plagues of pests reduce food crop yields. In agriculture, food crops are protected against disease either by chemical pesticides or by using biological methods of pest control.

CHEMICAL PESTICIDES

There are many **chemical pesticides** that are used to fight plant disease and pests. There are even pesticides for pests in gardens (see figure 70). Chemical pesticides are **biocides**. This means that they kill living organisms. The good thing about them is that they work very quickly. These agents can usually fight diseases and pests effectively.

But chemical pesticides do have a lot of drawbacks as well. They kill not only the harmful species, but often harmless and even useful ones too. These pesticides are **non-selective** (see figure 71). Developing selective biocides is complicated and therefore also expensive.

► Fig. 70 Chemical pesticides.

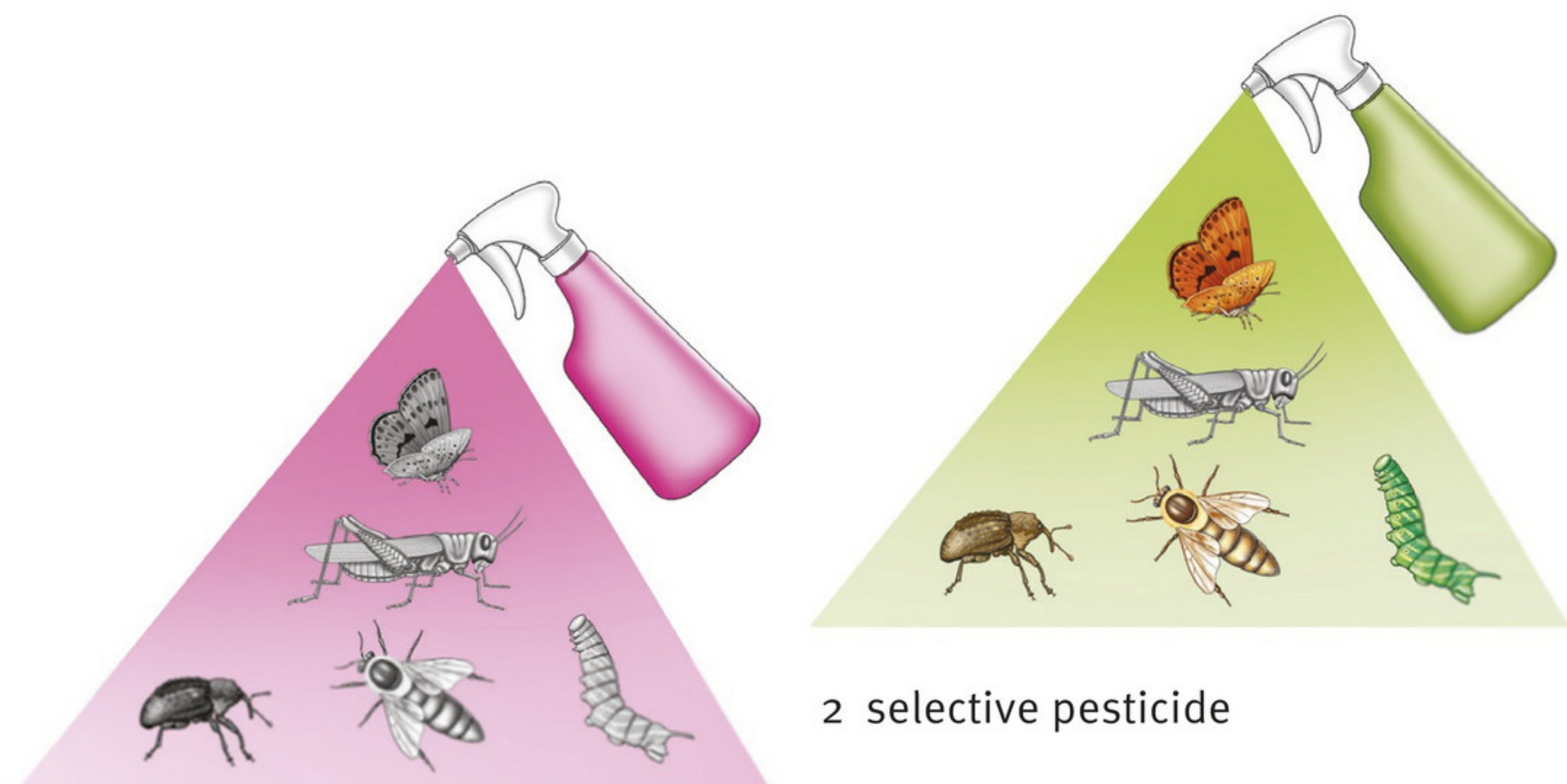


1 for use in agriculture



2 for use in and around the house

► Fig. 71



1 non-selective pesticide

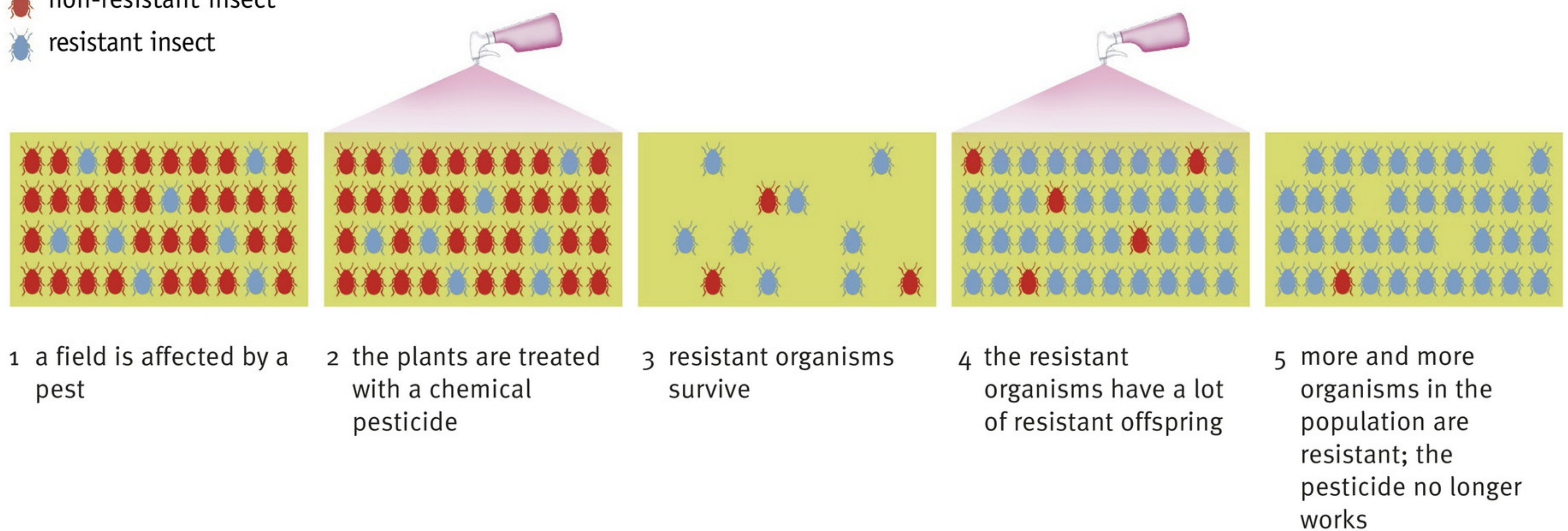
2 selective pesticide

Another disadvantage is that the pest species often develops **resistance** to the pesticide within a short time. In unit 5 (Inheritance and evolution) you learned that sexual reproduction leads to a range of different genotypes. The pest species often generates individual genotypes that make them insensitive or less sensitive to the pesticide used. These organisms are said to be **resistant**. These resistant organisms in particular will survive and reproduce (see figure 72). As a result, the entire species can become resistant to the pesticide after a number of generations. This will lead to a new plague. Larger quantities or different pesticides will then be needed for fighting this plague.

▼ **Fig. 72** The development of resistance to a chemical pesticide.

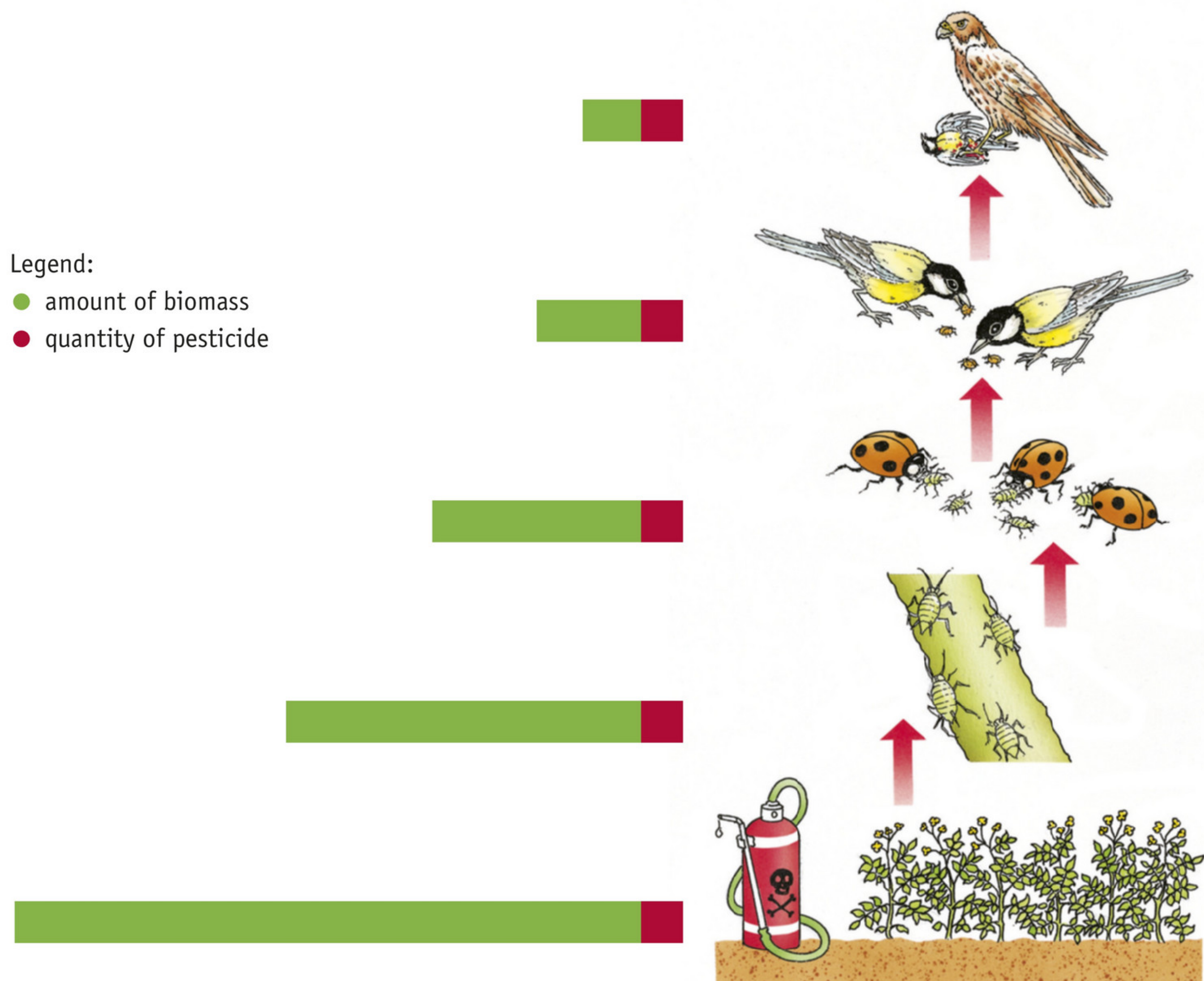
Legend:

-  non-resistant insect
-  resistant insect



A third disadvantage is that some of pesticides are non-biodegradable or take a very long time to decompose. In animals, pesticides are stored in fat tissues and passed up to the next link in the food chain. They also store the pesticides in their fat tissue. The pesticides are thus stored in the bodies of all the subsequent animals in the food chain. Finally, they build up in the animals at the end of the chain (see figure 73). This is called **accumulation**. In unit 6 (Ecology) you learned that the amount of biomass (the total quantity of energy-rich compounds) gradually decreases in the food chain. The same quantity of pesticide thus ends up in smaller and smaller amounts of biomass (see figure 73). As a result, the impact of the pesticides gets greater and greater. This is the reason why animals at the end of food chains are at greater risk of dying from pesticides.

▼ **Fig. 73** Accumulation of a chemical pesticide in a food chain (schematic).



▼ **Fig. 74** Whitefly.



► **Fig. 75** Parasitic wasp.



BIOLOGICAL PEST CONTROL

Biological pest control makes use of biological phenomena. Some insect species can be controlled by animals that are their enemies in nature. We call these animals **natural enemies**. The use of natural enemies is also referred to as **biological pest control**. An example of this approach is tackling whitefly using parasitic wasps.

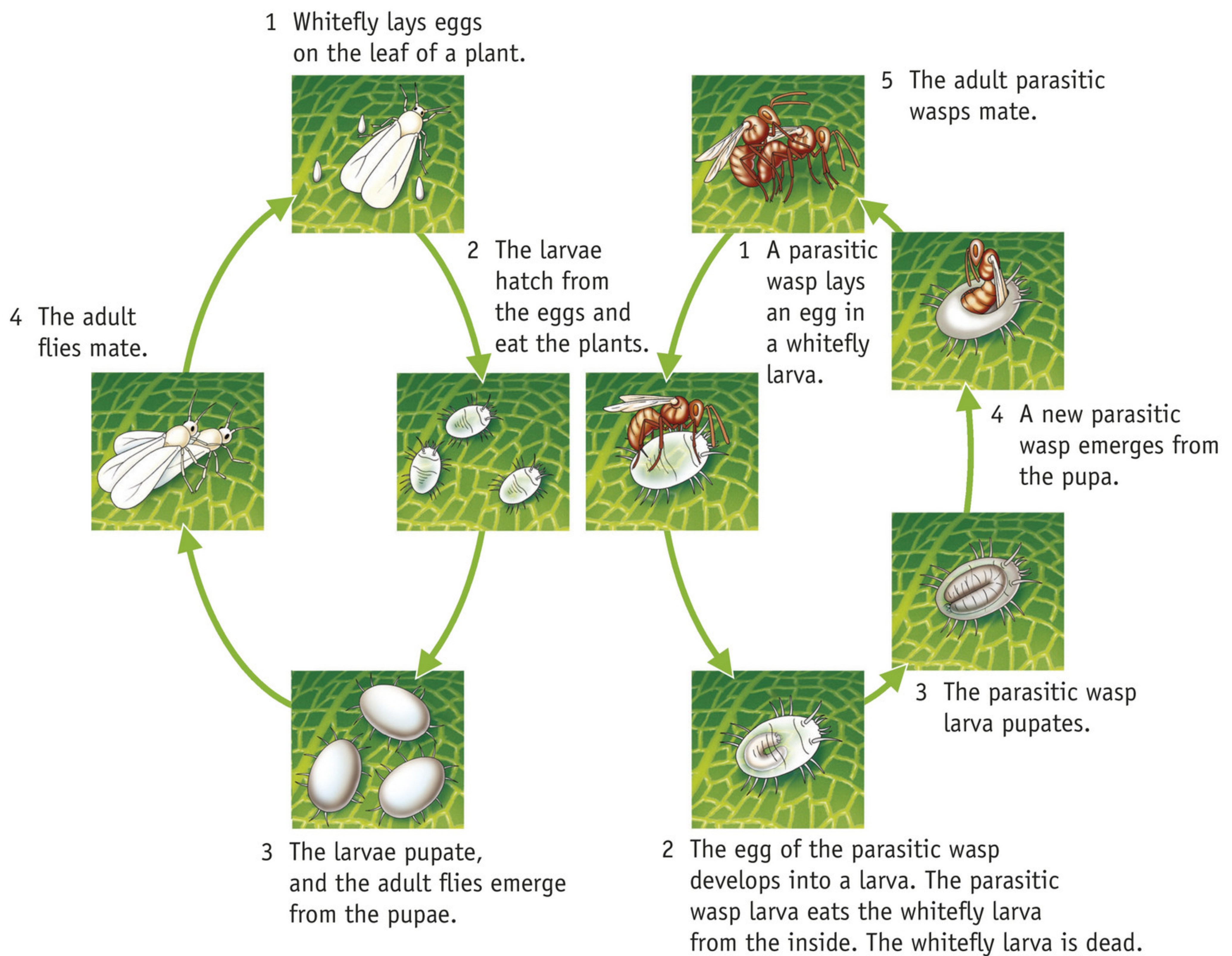
Whitefly can cause a lot of damage to crops such as tomatoes and cucumbers because they suck the sap from the plants (see figure 74). In order to fight whitefly, horticulturalists can release parasitic wasps in their greenhouses (see figure 75).

Figure 76 shows the control of whitefly using parasitic wasps. The horticulturalists buy the parasitic wasps from special suppliers. Eggs or pupae are often brought into the greenhouse rather than the grown animals (see figure 77).

Sounds or smells are also used to lure pests into traps. The trapped animals are then killed or made infertile. They can no longer reproduce and will not cause any further damage.

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▼ **Fig. 76** Biological control of whitefly using parasitic wasps.



► **Fig. 77** A card with eggs of parasitic wasps in a greenhouse.



8 Water and soil

Water and soil pollution led to numerous problems in the Netherlands in the twentieth century. Pollution is often a consequence of human activity. Many organisms depend on clean water and soil. Organisms that live in polluted environments can become threatened or disappear altogether. Clean water and soil are important for human beings as well. We drink water and eat crops that grow in the soil.

WATER POLLUTION

Water pollution in rivers, seas and lakes is not only caused by households but also by factories, agriculture, horticulture and shipping (see figure 78). Wastewater from factories often contains heavy metals such as zinc, cadmium and lead. These metals are harmful to human health and to animals.

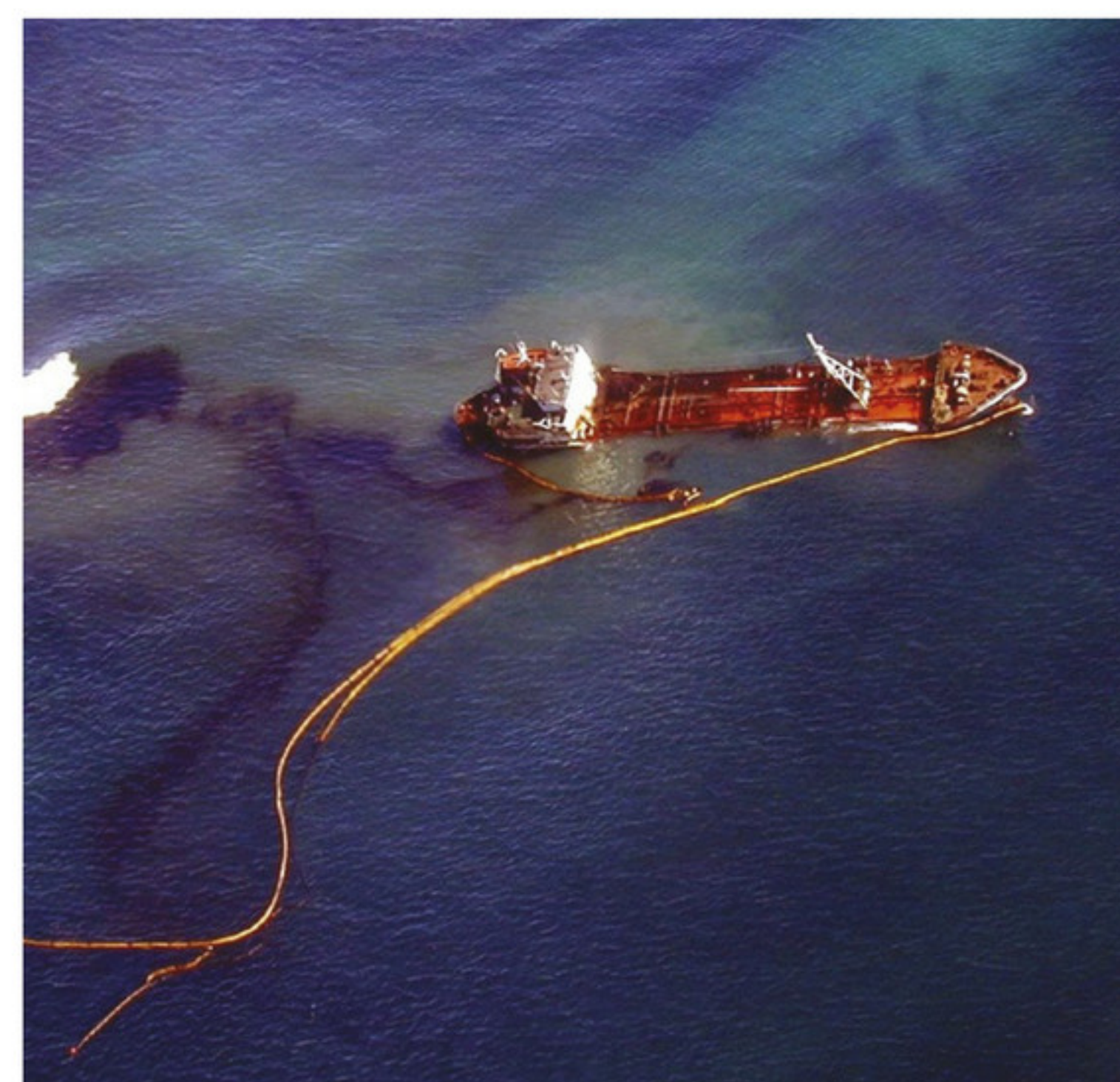
▼ **Fig. 78** Sources of water pollution.



1 factories



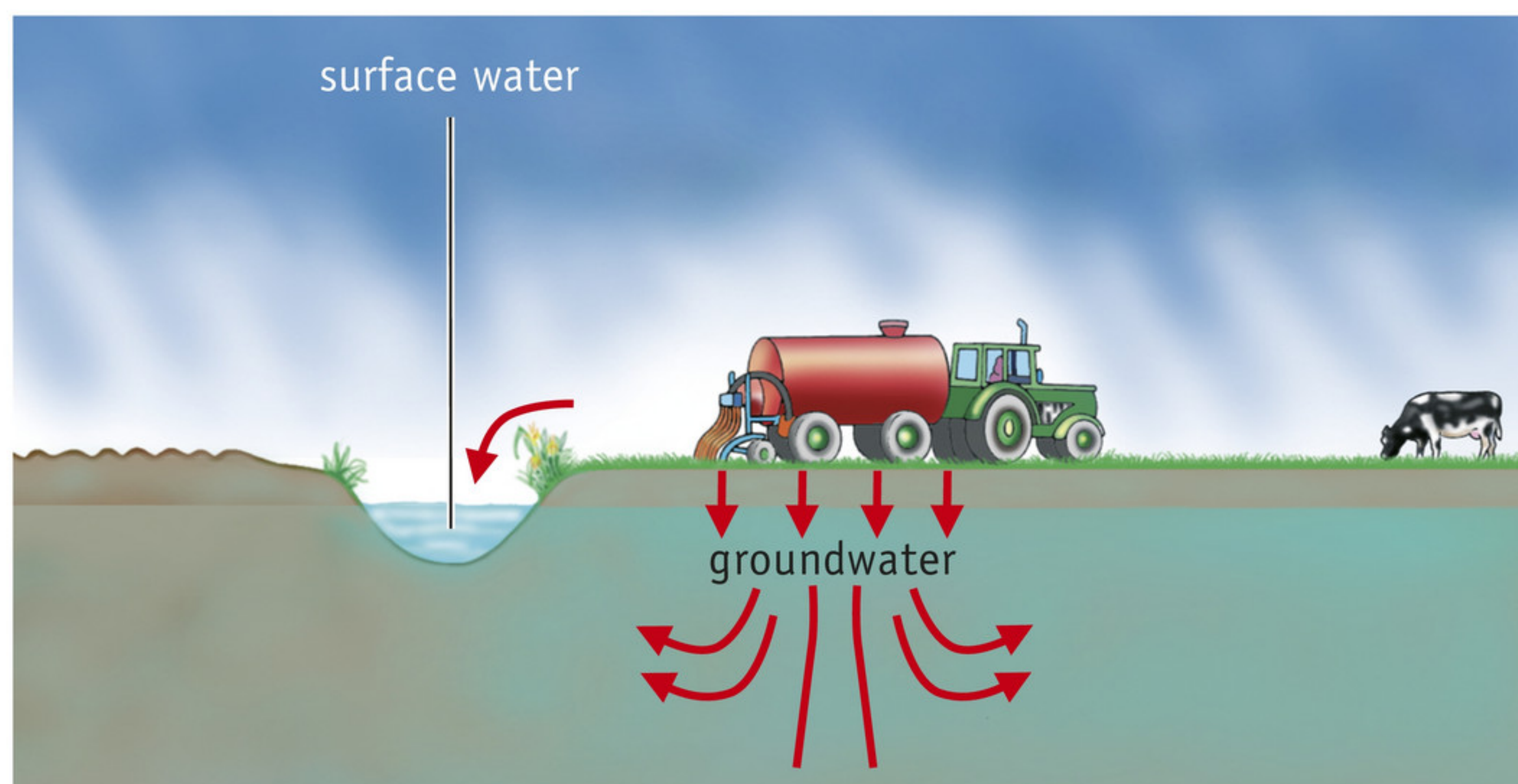
2 pesticides used in agriculture and horticulture



3 oil leaking from ships

Agricultural and horticultural enterprises also produce harmful substances that end up in our water and soil. Examples are chemical pesticides, manure and chemical fertilisers (see figure 79).

► **Fig. 79** Fertilisers can pollute groundwater and surface water.



In the past, a lot of pollution was caused by industry, agriculture and transport. Thanks to a wide range of measures, these cause less pollution nowadays. For example, ships and factories discharge less and less harmful substances into the environment. Instead they collect them and process them properly. Wastewater is often purified before it is discharged into surface waters. These measures help reduce water pollution.

▼ Fig. 80

Cleaning pollutants from water using banana skins

In 2011, scientists discovered a cheap and safe way of removing heavy metals from water: banana skins. Heavy metals such as lead and copper often end up in the water due to agricultural and industrial activity. These metals can enter the soil via the groundwater and become a hazard to public health. To purify the water again, substances are added to it that bind the heavy metals. After that, the water is filtered. Producing the binding substances is expensive and also produces a lot of polluted wastewater.

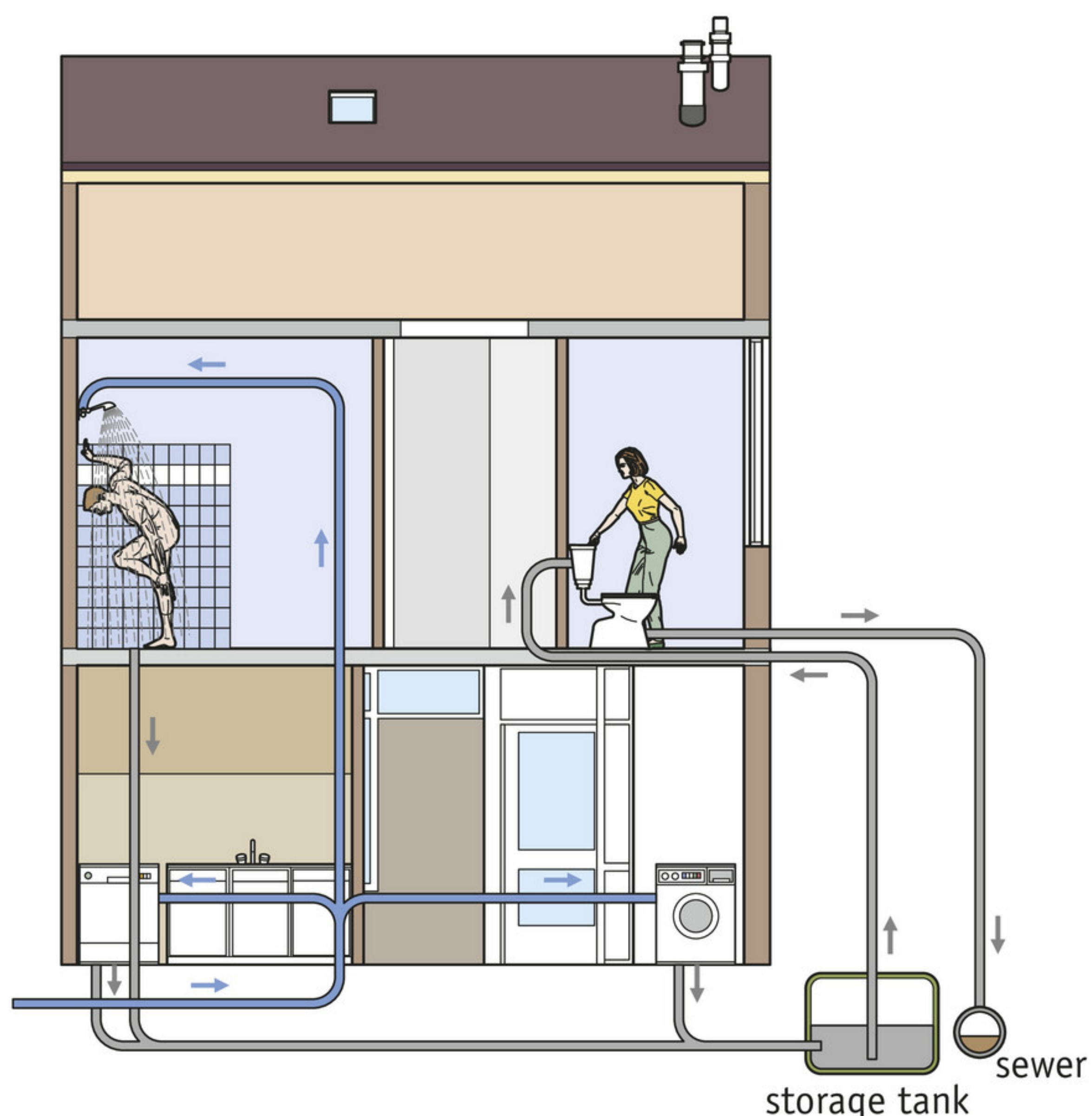
The scientist Gustavo Castro has a better and cheaper solution: banana skins. Castro and his colleagues knew that banana skins also contain substances that can bind metals. They dried banana skins and put them in water that contained heavy metals. They also built a water filter from banana skins and forced the polluted water through it. In both cases, the metals were removed from the water. The banana skins actually

turned out to do a better job than the substances that are currently used for purifying water. In 2013, Brazilian researchers from the University of São Paulo found that water polluted by pesticides can also be purified using banana skins.

From: *Scientias*, 14 March 2011 and *Trouw*, 10 May 2013.



▼ Fig. 81 A house that uses grey water.



WATER POLLUTION IN AND AROUND THE HOME

All households in the Netherlands produce polluted water. We all flush large quantities of faeces, urine, toilet paper and cleaning agents down the drain. This is called **household wastewater**. On average, every household discharges nearly four hundred litres of household wastewater into the sewers every day.

We use clean drinking water for nearly all purposes, but we could make more use of grey water as well. **Grey water** is only slightly contaminated wastewater from showers, washing machines and kitchens, for example. The name 'grey' refers to the colour of the water. It is grey because it contains some soap residues. This water is perfectly suitable for flushing the toilet, for instance. Figure 81 shows you a house that uses grey water.

SOIL POLLUTION

In many places, soil pollution has caused toxic substances to end up in the soil. Plants use their roots to absorb water from the soil. Unfortunately, toxic substances may be dissolved in this water as well. Plants then absorb not only the nutrients that they need for their growth, but also all kinds of toxins. This is how toxic substances get into food chains.

There are about 175,000 places in the Netherlands where the soil is so contaminated that it needs to be cleaned. In the past, waste from chemical industries used to be dumped on landfill sites. This is one of the causes of soil pollution. Another cause of soil pollution is transport. In the past, lead used to be added to petrol. This used to end up on roadside verges via the exhaust gases. Now that almost all cars run on unleaded petrol, less lead ends up in the soil. But the soil along motorways still contains relatively large amounts of lead.

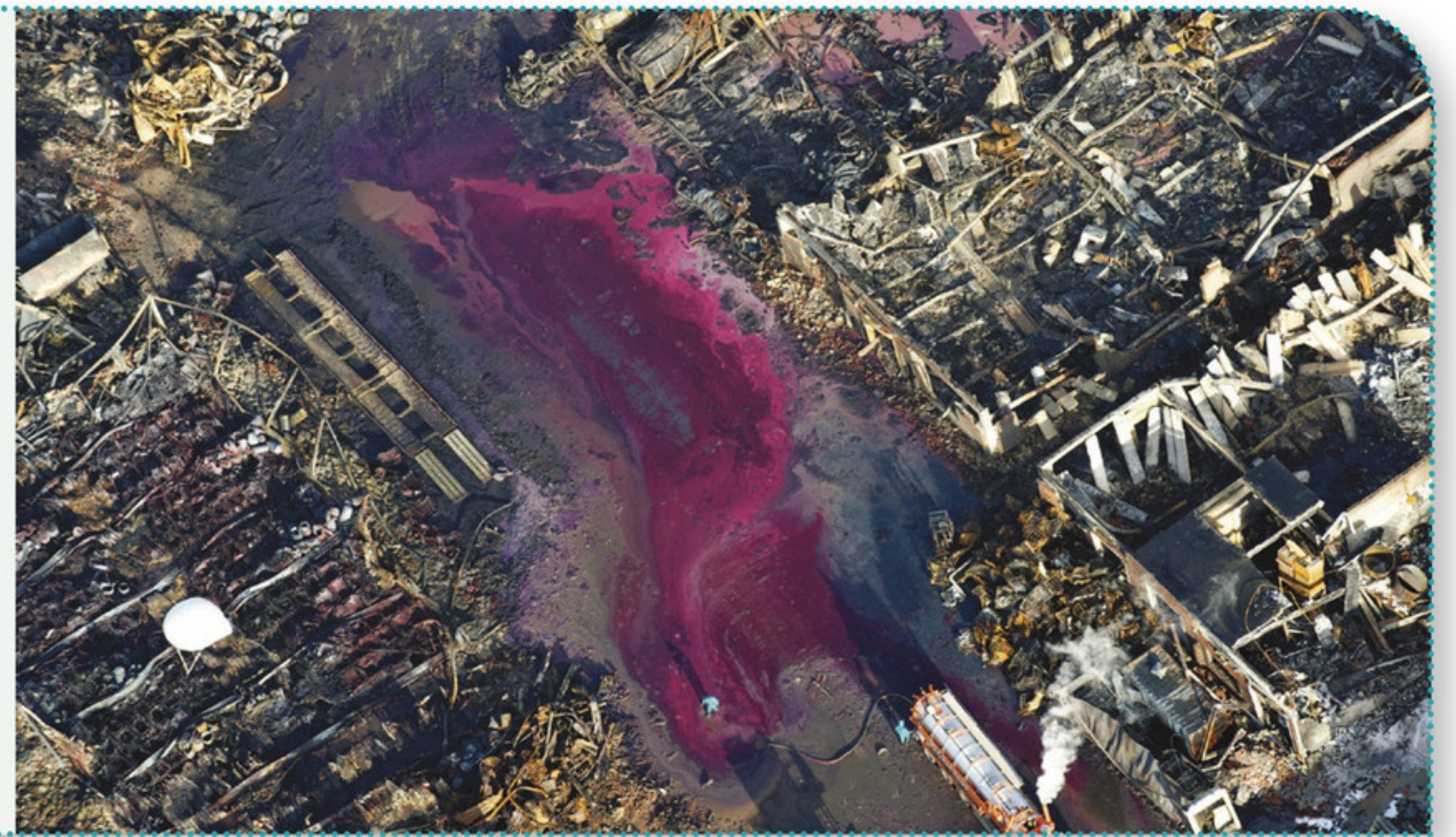
Projects for cleaning contaminated soil are regularly started up. **Soil remediation** takes a lot of time and costs a lot of money (see figure 82). The soil is often dug out and chemically cleaned. A cheaper method is biological soil remediation. This method uses bacteria that convert contaminants into harmless substances.

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▼ Fig. 82

Soil remediation at Chemie-Pack is going to take five to ten years

In 2011, a fire at a company in Moerdijk called Chemie-Pack released huge quantities of toxic substances that ended up in the soil. The soil remediation process has started and will take five to ten years. The costs have been estimated at roughly €40,000,000.



Summary

OBJECTIVE 1

You can give examples of ways in which humans depend on the environment.

- The environment provides food.
- The environment provides oxygen.
- The environment provides water.
- The environment provides energy.
- The environment provides raw materials.
- The environment provides a place for recreation.

OBJECTIVE 2

You are able to say how humans can change the environment. You can also list the main causes and consequences of environmental problems. You can explain what reintroduction is.

- Humans can change the environment by:
 - removing substances from the environment, which leads to depletion;
 - adding substances to the environment, which leads to pollution.
- Causes of environmental problems.
 - The enormous population growth: more and more space is needed for houses, transport and agriculture.
 - Changing lifestyles: there is a lot of industry, including chemical plants, there are a lot of machines and appliances and there is more transport.
- Consequences of environmental problems.
 - Stocks of energy are running out because of excessive energy consumption.
 - The environment is getting polluted by waste products.
 - Large chunks of nature are disappearing as more and more land is used for agriculture.
 - Biodiversity (the variation of species in nature) is decreasing: many plant and animal species have died out or are threatened with extinction.
- Reintroduction.
 - Reintroduction is bringing a plant or animal species back into an area.

OBJECTIVE 3

You can name the key sources of energy as well as their advantages and disadvantages.

- Fossil fuels were created millions of years ago from the remains of dead plants and animals.

- The energy in fossil fuels comes ultimately from the sun.
- Energy is released during the combustion of fossil fuels.
- Natural gas, petroleum and coal are fossil fuels.
- Advantages of fossil fuels.
 - Extracting them from the ground is relatively cheap.
 - They are easy to transport and consume.
- Disadvantages of fossil fuels.
 - Burning them releases carbon dioxide and other waste products.
 - Carbon dioxide is one of the causes of global warming.
 - Fossil fuels will be used up in the long run.
- Nuclear power is released when atomic uranium nuclei are split apart.
 - Nuclear power is used for generating electricity.
- Advantages of nuclear power.
 - It can generate a lot of electricity.
 - It does not cause air pollution.
 - No carbon dioxide is released.
- Disadvantages of nuclear power.
 - It produces radioactive waste.
 - A lot of radioactivity can be released if an accident happens.
- Sustainable (renewable) energy.
 - Biomass can be used as fuel.
 - Biofuels (e.g. alcohol, diesel) can be made from plants.
 - Wind power can be used by wind turbines.
 - Solar power can be used by solar boilers and solar panels.
 - Water power (e.g. for hydroelectric energy) can be used by building dams.
- Advantages of sustainable energy.
 - The energy sources do not get depleted.
 - The energy sources cause much less environmental pollution.
 - Burning biomass and biofuels does not release extra carbon dioxide into the air.
- Disadvantages of sustainable energy.
 - A lot of agricultural land is needed for growing crops for biofuels.
 - There is not always enough sunshine and wind to generate enough energy.
 - Some people believe that wind turbines cause skyline pollution.
 - Building hydroelectric power plants (with an artificial lake behind a dam) has a major impact on the environment.

- The Netherlands is very flat, so it is not possible to generate much energy from hydroelectric power.

OBJECTIVE 4

You can describe what the greenhouse effect is and which factors enhance the greenhouse effect.

- Greenhouse effect: some of the heat energy radiated by the Earth is trapped by the greenhouse gases in the atmosphere.
 - Without the greenhouse effect, the temperature on Earth would be at least 30°C lower.
 - The most important greenhouse gases are carbon dioxide and water vapour.
- Enhanced greenhouse effect: the greenhouse effect is amplified when more greenhouse gases are released into the atmosphere.
 - Increases in energy consumption mean that more and more coal, petroleum, petrol and natural gas are being burned. This means that more carbon dioxide is released into the atmosphere.

OBJECTIVE 5

You can name the causes and consequences of climate change.

- Climate change: change in the weather type for a number of years.
- Cause of climate change: the enhanced greenhouse effect and the resulting increase in the Earth's temperature.
- Consequences of climate change.
 - Rising sea levels because seawater expands when it gets warmer and because some Antarctic ice and glacier ice will melt. As a result, low-lying areas could get flooded.
 - Deserts will get larger as a result of drought.
 - In some areas agriculture will become impossible, while other areas will become more suitable for agriculture.
 - Certain plants and animals will disappear, while other species will appear.
 - Disruption of the annual rhythm of species: some species appear earlier in the year, others do not. Food chains can be disrupted as a result.
 - Some diseases will occur more often, for example Lyme disease.

OBJECTIVE 6

You can describe the influence that ozone in the atmosphere has on life on Earth. You can also list the causes and consequences of the damage to the ozone layer and of summer smog.

- The atmosphere is made up of the troposphere and the stratosphere.
 - Troposphere: the atmosphere up to a height of 12 km.
 - Stratosphere: the atmosphere at heights of 12 to 50 km.
- Ozone is a gas that is formed from oxygen.
 - Ozone layer: a layer in the stratosphere with a lot of ozone.
 - The ozone layer blocks a large proportion of harmful ultraviolet radiation in sunlight.
- Cause of the damage to the ozone layer: emissions of CFCs (chlorofluorocarbons) into the air.
 - CFCs from refrigeration elements of old fridges and freezers.
 - CFCs from aerosols.
- Consequence of the damage to the ozone layer.
 - More cases of skin cancer because more ultraviolet radiation reaches the Earth's surface.
- Smoke and exhaust gases can cause smog and acidification.
 - Smog is a kind of fog that is heavily polluted by smoke and exhaust gases.
- There is a difference between summer smog and winter smog.
- Summer smog is fog polluted by particulate matter, acidifying gases and ozone.
- Cause of summer smog.
 - When the weather is hot and the sun is shining, chemical reactions take place between the combustion products of fossil fuels, creating ozone.
- Consequences of summer smog.
 - Irritation of the mucous membranes of the airways.
 - The ozone in summer smog enhances the greenhouse effect.
- Winter smog is fog polluted by particulate matter.
- Cause of winter smog.
 - When the weather is cold, houses and buildings are heated by burning fossil fuels. Particulate matter is released during this combustion.
- Particulate matter contains particles of various origins and sizes that are floating in the air.
- Sources of particulate matter.
 - nature.
 - human activity (transport and industry): exhaust gases, wood-burning stoves, barbecues and fireworks.

- Consequences of particulate matter.
 - Particulate matter has been linked to cardiovascular disease and lung conditions. The smallest particles are most harmful because they get deeper into the lungs.
- Acidification of the environment (acid rain) is caused by burning fossil fuels.
 - Consequence: plants can get diseases and die.
- Measures for keeping the air clean.
 - Cars are fitted with catalytic converters so that fewer acidifying gases are emitted into the air.
 - Flue gases from factories are purified so that less particulate matter is released into the air.
 - In poultry farming, particulate matter in the air is removed by air scrubbers.

OBJECTIVE 7

You can explain the difference between biodegradable and non-biodegradable waste.

- Biodegradable waste: waste that can be degraded by decomposers (bacteria and fungi).
 - Waste residues from plants, animals or humans.
 - Waste from products made from parts of plants or animals.
 - Examples: leaves, droppings, fruit peel, bread crusts, paper.
- Non-biodegradable waste: waste that cannot be degraded by decomposers.
 - Waste from products made from glass, metal, stone or plastics such as nylon or polystyrene.
 - Only humans produce non-biodegradable waste.
 - Examples: wine bottles, batteries, rubble, shampoo bottles.

OBJECTIVE 8

You can describe the methods of separate waste collection and waste treatment.

- Separate waste collection makes environment-friendly processing possible.
 - Organic waste in an organic waste bin.
 - Paper and cardboard in special waste paper containers or to groups that come and collect it.
 - Glass, cans, plastics, plastic bottles and textiles in special bins or containers.
 - Small-scale chemical waste to waste collection points or specialist companies.
- Separated waste can be incinerated, dumped or used for new purposes.
 - Recycling, re-use and composting are ways of processing waste for new purposes.

- Recycling: waste products are used as raw materials for making new products (glass, paper, cans, plastics and other synthetic materials).
 - Environmentally friendly because it saves on raw materials.
- Composting: decomposers to reduce biodegradable waste into compost.
 - Compost is used as a garden fertiliser.
 - Environmentally friendly because nutrients from organic waste are given back to plants.
- Waste processing by burning it in incinerators.
 - Advantages: does not need much space and can generate electricity.
- Waste processing by dumping on a landfill site.
 - Advantages: simple and cheap.
 - Disadvantages: smells very bad and attracts vermin.

OBJECTIVE 9

You can explain what agriculture is and describe (intensive) agriculture in the Netherlands.

- Agriculture: activities that change the natural environment for producing plants and animals for use by humans.
- Three types of agriculture: arable farming, livestock farming, horticulture.
- Mixed farms: farms with both arable farming and livestock farming.
- Food crops: plants that are grown in agriculture and horticulture for food.
- Farm animals: animals that are kept for livestock farming.
- Grazing farm: farm with cows, sheep, goats or horses.
- Features of arable farming.
 - Large farms with a lot of land.
 - The food crops are grown in monocultures.
 - Monoculture: a large field where just one crop is grown.
- Advantages of monocultures.
 - Large machines can be used for working the soil and for harvesting. This means that the crop can be grown cheaply.
- Disadvantages of monocultures.
 - High risk of insect pests and plant disease. Chemical pesticides are used to prevent this.
 - Chemical pesticides are toxic substances that kill harmful organisms.
 - The pesticides often kill useful organisms as well.

- Pesticides may end up in our drinking water.
- The soil is quickly exhausted. A lot of organic fertilisers (manure from organisms) and chemical fertilisers are therefore used. Fertilisers can get into our drinking water.
- Features of intensive livestock farming (factory farming).
 - Feed is not grown by the livestock farmers themselves, but bought from suppliers (70% of the raw materials for the production of feed come from abroad).
- Advantages of factory farming.
 - The farms produce a lot (meat, milk or eggs).
- Disadvantages of factory farming.
 - Generally, the animals do not have a pleasant life.
 - There is a manure surplus most of the time.
 - Gases from the manure cause acidification of the environment and worsen the greenhouse effect.
- Features of horticulture.
 - Horticulture is often practised in greenhouses (greenhouse horticulture) instead of in the open field.
 - Conditions in the greenhouses are favourable: the crops get exactly the right amount of water, nutrients, warmth and light.
- Advantages of greenhouse cultivation.
 - Yields from the crops are maximised.
 - Crops can be grown all year round.
- Disadvantages of greenhouse horticulture.
 - A lot of energy is used for growing the crops.
 - The carbon dioxide that is released during the combustion of natural gas enhances the greenhouse effect.

OBJECTIVE 10

You can describe advantages and disadvantages of the fishing industry and fish farming and explain the advantage of eating insects.

- The fishing industry: fish are caught in open water (sea, lake or river).
 - Bycatch: unwanted kinds of fish that are also caught unintentionally. The bycatch is often discarded. The fish in the bycatch can get injured or killed.
- Overfishing: catching too much fish in a certain area as a result of improved fishing techniques.
 - Quota: the quantity of a certain species of fish that a country is allowed to catch.
- Fish farming: breeding fish in special tanks or cages.

- Advantages of eating insects:
 - much less (agricultural) land is needed for the production;
 - less feed is needed than in regular livestock farming;
 - less manure is produced.

OBJECTIVE 11

You can describe organic farming and name the advantages and disadvantages.

- Features of organic farming.
 - There are no monocultures.
 - Chemical fertilisers are not used.
 - No chemical pesticides are used (fruits and vegetables are not sprayed).
 - Diseases due to soil organisms are prevented by crop rotation: the same crop is never grown in the same field for two years in a row.
 - The animals have space to run free (free-range chickens and pigs).
- Advantages of organic farming.
 - It is environmentally friendly.
 - The animals have a better life.
- Disadvantage of organic farming.
 - The products are often a bit more expensive.

EXTRA OBJECTIVE 12

You can name the features of chemical and biological pest control.

- Chemical pest control.
 - By biocides: pesticides that kill organisms.
- Advantages of chemical pest control.
 - Quick effect (disease and pests can be tackled effectively).
- Disadvantages of chemical pest control.
 - Many biocides are non-selective: they kill many species of organisms, including harmless and useful ones.
 - Pests become resistant: organisms that are insensitive to pesticides (or for the quantity used) stay alive and reproduce.
 - Other animals suffer from accumulation: the biocides accumulate in food chains because they are not broken down biologically (or only very slowly). Animals at the top of a food chain in particular suffer from the accumulation of pesticides.

- Biological pest control.
 - By using natural enemies: for example fighting whitefly using parasitic wasps.
 - By luring animals into traps by means of smells (for example sexual attractants) or sounds: the trapped animals are killed or made infertile.
 - By crop rotation.

EXTRA OBJECTIVE 13

You can list causes and consequences of water and soil pollution.

- Water pollution in rivers, seas and lakes is caused by households, factories, agriculture, horticulture and shipping.
 - Household wastewater contains faeces, urine, toilet paper and cleaning agents, amongst other waste products.
 - Grey water is slightly contaminated household wastewater from showers, washing machines and kitchens, for example.
 - Grey water is suitable for flushing the toilet.
 - Wastewater from factories can contain heavy metals.
 - Wastewater from agriculture and horticulture can contain chemical pesticides and chemical fertilisers.
- Sewage consists of rainwater and household wastewater and is purified in sewage treatment plants.
- Soil pollution is caused by human activities, industry, transport and agriculture.
 - Soil remediation: cleaning the soil.
 - Biological soil remediation: bacteria convert contaminants in the soil into harmless substances. This is a cheaper method.

SKILLS AND COMPETENCIES**BASICS**

- You have practised reading and/or making graphs.
- You have practised getting information from articles and images.
- You have practised carrying out an investigation.

EXTRA

- You have practised making a food pyramid.
- You have practised getting information from articles and images.

The diagnostic test does not include any questions about these competencies/skills.

You have met a toxicology analyst and an environmental technologist in this unit. You have also seen applications in science and daily practice that use the material from this unit.

Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the scoresheet in your workbook.

OBJECTIVE 1

Answer the following multiple choice questions.

- 1 Sophie says that humans depend on the environment for raw materials.
Anne says that the environment is important as a place for recreation.
Who is right?
 A Both of them are right.
 B Only Sophie is right.
 C Only Anne is right.
 D Neither of them is right.

- 2 Three ways are stated below in which humans depend on the environment.
 - 1 The environment provides food.
 - 2 The environment provides water.
 - 3 The environment provides oxygen.
 In which of these ways does photosynthesis play a direct role?
 A Only 1 and 2.
 B Only 1 and 3.
 C Only 2 and 3.
 D 1, 2 and 3.

OBJECTIVE 2

Say whether each of the following statements is true or false.

- 1 The only cause of environmental problems is the growth of chemical industries.
- 2 The enormous population growth has contributed to the rise of environmental problems.
- 3 Figure 83 shows an important environmental problem.
- 4 A lot of nature has disappeared because more and more land is being used for agriculture.
- 5 In the past hundred years, biodiversity in the Netherlands has increased.
- 6 Biodiversity is increased by adding substances to the environment.
- 7 Thanks to a reintroduction programme, wolves are back in the Netherlands (see figure 84).

▼ Fig. 83



▼ Fig. 84



OBJECTIVE 3

Answer the following questions.

- 1 The article in figure 85 says that CH Energy is going to make fossil fuels from items such as old frying fat. Explain that this is incorrect.

▼ Fig. 85

Company makes petrol from used frying fat

CH Energy, a company in Wijster, is going to make fossil fuels such as petrol, kerosene and diesel out of used frying fat. Later it may be possible to use car tyres and plastics as raw materials too.

Figure 86 shows an article about hydrogen. Questions 2 and 3 are about this article.

- 2 Is hydrogen always a sustainable energy source? Explain your answer.
- 3 What sustainable energy source is most widely used in the Netherlands for generating electricity?

▼ Fig. 86

Buses running on hydrogen

Hydrogen can be used as fuel for buses. Combustion of hydrogen produces no carbon dioxide – just water. However, carbon dioxide usually does get released during the production of hydrogen. Hydrogen can be made from fossil fuels or biomass, for example, or from water using sustainable electricity.

Buses can also run on electricity alone, but the batteries needed for this are very heavy. As a result, more energy is needed for driving. The batteries also run out quickly and it takes a long time to recharge them fully. When hydrogen is used, no batteries are needed.



- 4 Figure 87 shows an article about biofuel. What is the main disadvantage of first-generation biofuels?
- 5 Why do second-generation biofuels not compete with food?
- 6 What is the ultimate origin of the energy in biofuel?
- 7 What process meant that this energy ended up in plants?
- 8 During the combustion of biofuel, carbon dioxide is released as well. Why do biofuels nevertheless not contribute to global warming?

▼ Fig. 87

Biofuel

Plants produce all sorts of substances that could be put into car fuel tanks after suitable processing. Brazil adds alcohol from sugar cane to the first-generation biofuels, for instance. The United States add alcohol from corn and Sweden adds alcohol from grains to the fuels.

Second-generation biofuels are being used now as well. In these biofuels, not only the sugary parts of plants are converted into alcohol, but the woody parts too.

OBJECTIVE 4

Answer the following multiple choice questions.

- 1 Which of the changes in the atmosphere listed below is responsible for the enhanced greenhouse effect, according to many scientists?
 - A A decrease in the carbon dioxide level.
 - B An increase in the carbon dioxide level.
 - C An increase in the ozone level.
 - D An increase in the evaporation of water.
- 2 How do greenhouse gases cause the greenhouse effect?
 - A Greenhouse gases trap some of the gases released during the combustion of fuels.
 - B Greenhouse gases trap some of the gases released during photosynthesis.
 - C Greenhouse gases trap some of the heat energy radiated away by the Earth.
 - D Greenhouse gases block some of the solar radiation from reaching the Earth's surface.
- 3 Two statements are given below about climate change.
 - 1 Higher average temperatures make cold areas less suitable for agriculture.
 - 2 As a result of longer periods of drought, deserts are getting larger.
 Which of these statements are true?
 - A Both statements are false.
 - B Only statement 1.
 - C Only statement 2.
 - D Both statements are true.

▼ Fig. 88

Indonesian companies suspected of causing fires

Eight plantation companies in Indonesia are suspected of illegal deforestation by arson, thus making land available for the palm oil industry. The fires, which have been raging for several days now, caused a huge amount of air pollution in the neighbouring countries Singapore and Malaysia. The air quality there has dropped to a level classified as 'unhealthy'.

- 4 Figure 88 shows a newspaper article about forest fires in Indonesia. Do these forest fires cause a decrease or an increase in the greenhouse effect? And do they cause a decrease or an increase in the quantity of particulate matter?
- A A decrease in the greenhouse effect and a decrease in the quantity of particulate matter.
 - B A decrease in the greenhouse effect and an increase in the quantity of particulate matter.
 - C An increase in the greenhouse effect and a decrease in the quantity of particulate matter.
 - D An increase in the greenhouse effect and an increase in the quantity of particulate matter.

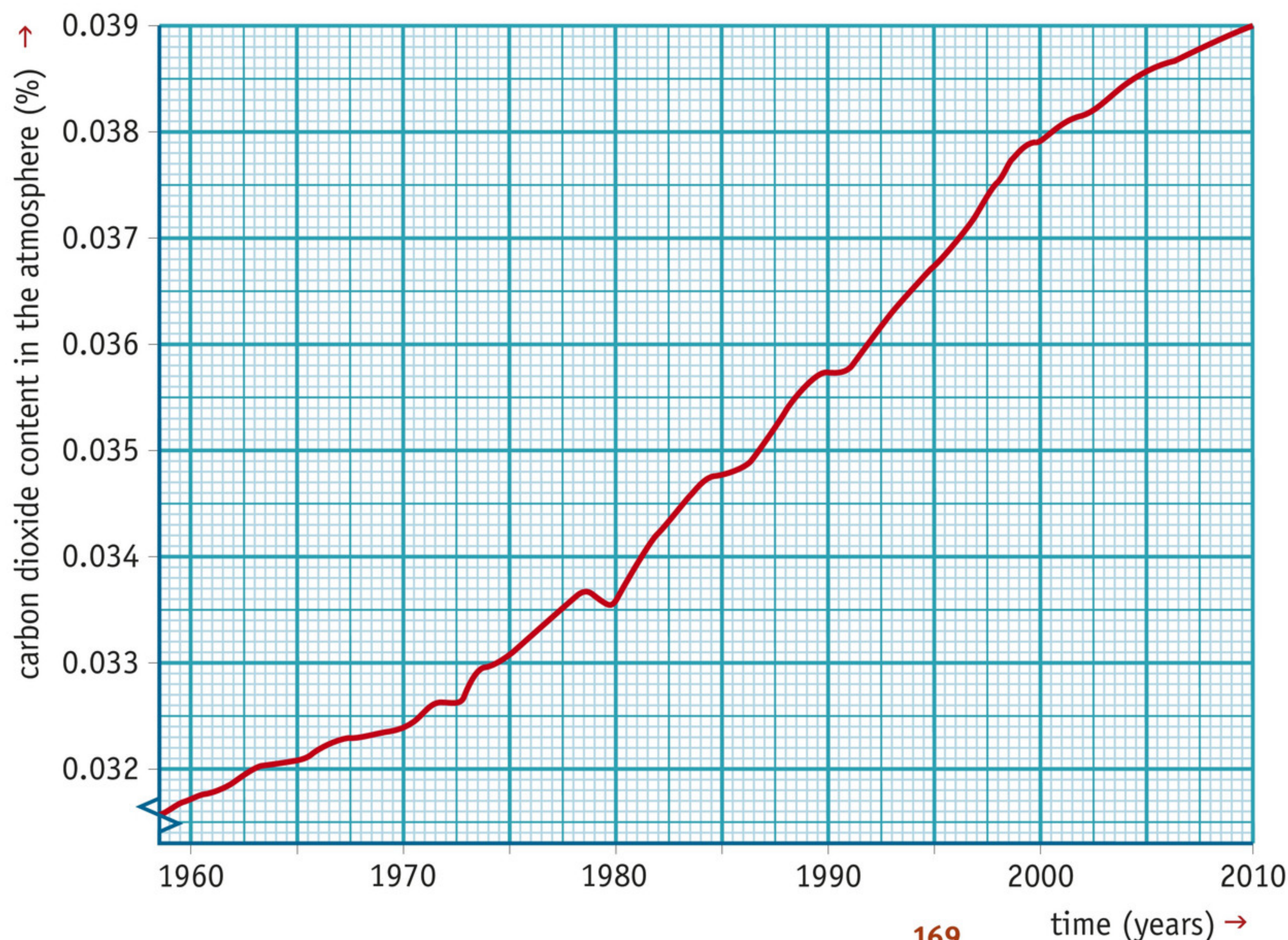
- 5 The graph in figure 89 shows the change in the carbon dioxide level in the atmosphere over the period 1960 to 2010. What was the consequence of this change for the greenhouse effect? And for the average temperature on Earth?
- A It has caused a decrease in the greenhouse effect and a decrease in the average temperature too.
 - B It has caused a decrease in the greenhouse effect, but an increase in the average temperature.
 - C It has caused an increase in the greenhouse effect and an increase in the average temperature too.
 - D It has caused an increase in the greenhouse effect, but a decrease in the average temperature.

OBJECTIVE 5

Say whether each of the following statements is true or false.

- 1 Figure 90 shows that the Netherlands is undergoing climate change.
- 2 Rising sea levels prove that we are experiencing climate change.
- 3 As a result of the enhanced greenhouse effect, the average temperature on Earth is decreasing.
- 4 The fact that deserts are expanding is caused by climate change.
- 5 As a result of climate change, some areas are becoming more suitable for agriculture.
- 6 As a result of climate change, the moment when birds lay their eggs is better timed to match the available food supplies.

▼ Fig. 89 Change in the carbon dioxide content in the atmosphere.



- 7 As a result of climate change, some diseases are occurring more often in the Netherlands.

▼ **Fig. 90** The average temperature in De Bilt over periods of ten years.

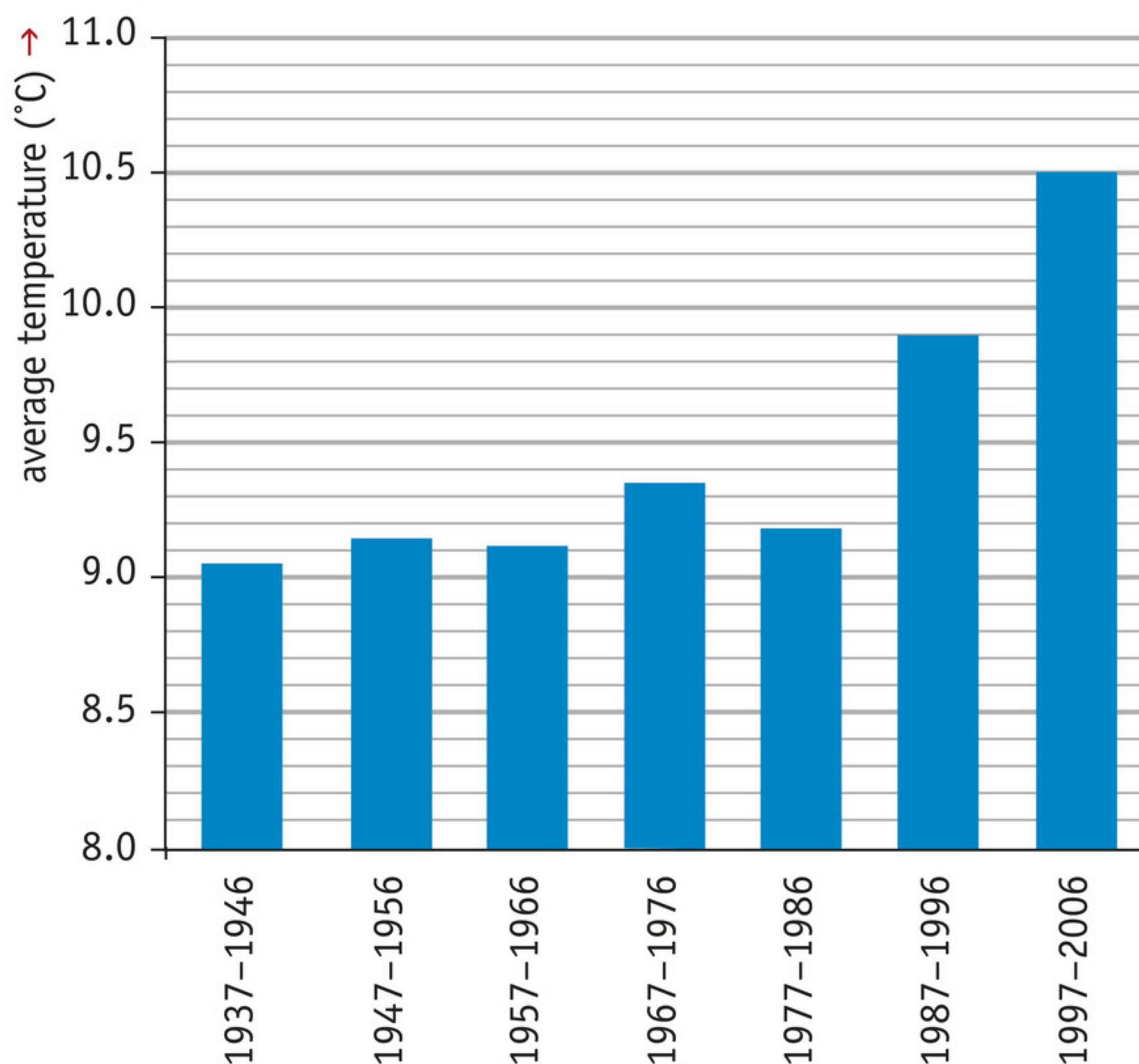


Figure 91 is an article about the wasp spider. The article shows that this spider is appearing further and further to the north.

- 8 The fact that the wasp spider is moving further to the north could be caused by climate change.

▼ **Fig. 91**

Wasp spider

The wasp spider is one of the species in Europe that is spreading northwards. This spider was first noted in Gulp in South Limburg in 1980.

Since then it has been moving further and further to the north.

The spider is now found mainly in the Limburg, East Brabant and Gelderland. But it has now been spotted a number of times in all other parts of the Netherlands too.



OBJECTIVE 6

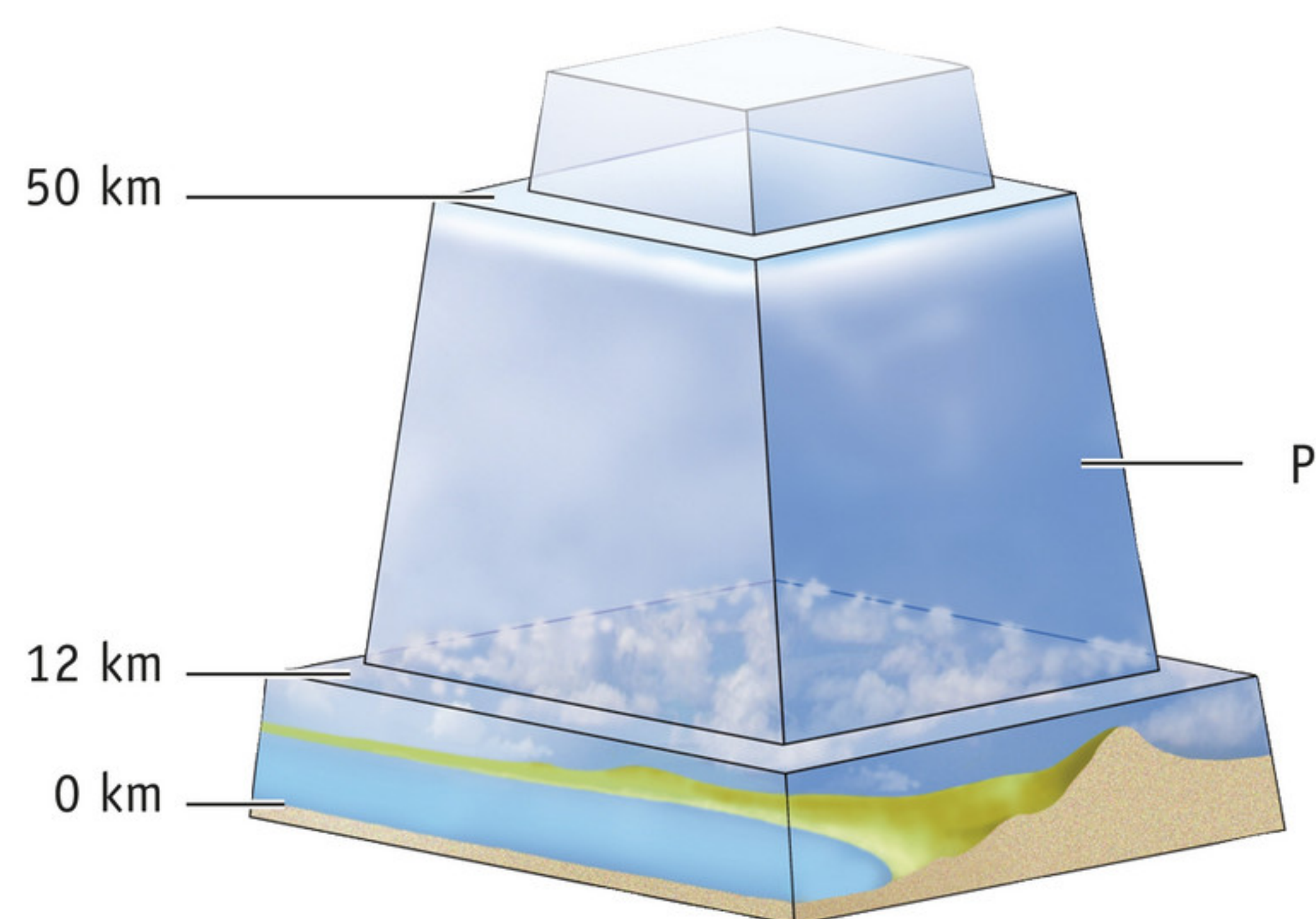
Answer the following multiple choice questions.

- 1 Figure 92 is a diagram of the atmosphere.

Does P indicate the troposphere or the stratosphere? Is there any ozone in P?

- A P indicates the stratosphere; this does contain ozone.
- B P indicates the stratosphere; this does not contain any ozone.
- C P indicates the troposphere; this does contain ozone.
- D P indicates the troposphere; this does not contain any ozone.

▼ **Fig. 92**



- 2 From what gas is the ozone in the ozone layer formed?

- A Ammonia.
- B Carbon dioxide.
- C Water vapour.
- D Oxygen.

- 3 Two students are talking about ozone.

Oscar says that damage to the ozone layer increases the risk of skin cancer.

William says that the ozone in summer smog enhances the greenhouse effect.

Who is right?

- A Neither of them is right.
- B Only Oscar is right.
- C Only William is right.
- D Both of them are right.

- 4 In what weather conditions is smog the most likely to occur?

- A In cold weather.
- B When it is rainy.
- C When there is no wind.
- D In stormy weather.

- 5 What government measures have contributed to a cleaner air?
- A Catalytic converters in the exhausts of cars and extractors in chimneys.
 - B Catalytic converters in the exhausts of cars and filters in chimneys.
 - C Catalytic converters in the exhausts of cars and the installation of filters in poultry farms.
 - D Catalytic converters in the exhausts of cars and air scrubbing in chimneys.

OBJECTIVE 7

The scoresheet has a table of two types of waste. Answer the following questions by placing crosses in the correct column.

- 1 What type of waste can be broken down by bacteria and fungi?
- 2 What type of waste is only produced by humans?
- 3 What type of waste is a scrap car?
- 4 What type of waste is dog mess?
- 5 What type of waste is a fallen tree branch?
- 6 What type of waste is the waste shown in figure 93?

▼ Fig. 93



- 7 What type of waste is the waste shown in figure 94?

▼ Fig. 94



- 8 What type of waste is the waste shown in figure 95?

▼ Fig. 95



OBJECTIVE 8

Say whether each of the following statements is true or false.

- 1 The containers shown in figure 96 are meant for separate waste collection.

▼ Fig. 96



- 2 The waste shown in figure 97 belongs in the organic waste container.

▼ Fig. 97



- 3 The waste shown in figure 98 can be handed in at the waste collection point.
- 4 Decomposers play an important role in the recycling of glass.
- 5 An easy and cheap way of processing waste is dumping it on a landfill site.
- 6 Electricity can be generated by composting waste.
- 7 Burning waste in incinerators releases combustion products that can be used as garden fertilisers.

▼ Fig. 98



OBJECTIVE 9

Say whether each of the following statements is true or false.

- 1 Figure 99 shows an example of a monoculture.
- 2 Monocultures reduce the risk of insect pests.
- 3 Large arable farms use mostly farmyard manure for fertilising the land.

▼ Fig. 99



- 4 Using chemical fertilisers on agricultural land causes water pollution.
- 5 Thanks to factory farming, more food is being produced in the Netherlands than before.
- 6 In intensive livestock farming, a large proportion of the land is used for growing animal feed.

▼ Fig. 100



- 7 Figure 100 shows how chickens are kept in factory farming.
- 8 Thanks to greenhouse cultivation, a lot of vegetables can be bought all year round.
- 9 Less energy is needed for growing vegetables in greenhouses than for growing them in open fields.
- 10 Crops grow well in greenhouses thanks to the bright lights (see figure 101).

▼ Fig. 101



- 11 Chemical pesticides only kill the harmful insects.
- 12 There is usually no manure surplus in factory farming.

OBJECTIVE 10

Answer the following questions.

- 1 Is the bycatch an issue in the fishing industry or in fish farming? Explain your answer briefly.
- 2 What is the main cause of overfishing? Explain your answer.

- 3 What important measure is used for limiting catches? Please also explain briefly what this measure involves.
- 4 Figure 102 is an article about the yellowtail kingfish. What makes this fish suitable for fish farming?

▼ Fig. 102

The ideal fish for breeding

The yellowtail kingfish looks like tuna and swordfish and turns out to be ideal for breeding in fish farms: it is strong, it is stress-resistant and it grows fast. On top of that, this saltwater fish lives in schools and is used to having a lot of fish in just a little space.

Wageningen University is leading a study to find out how these fish could be farmed sustainably in the Netherlands. The mere fact that the fish will be bred in the Netherlands is in itself a sustainable development: the fish are being imported from Australia at the moment, which has much more impact on the environment, of course.



- 5 Explain why breeding yellowtail kingfish is sustainable.
- 6 Insects are a good source of protein.
Write down three other advantages of eating insects.

OBJECTIVE 11

Answer the following questions.

- 1 Explain what crop rotation is.
- 2 Explain why organic meat is often a bit more expensive than regular meat (see figure 103).
- 3 A newspaper article says the following about organic flower bulbs: "A number of horticulturalists have switched to organic cultivation for flower bulbs. The product range includes roughly fifty different types of hyacinths, crocuses, lilies, daffodils and tulips." What kind of pest control do these horticulturalists use for their flowers?

▼ Fig. 103



- 4 Figure 104 is an article about crop rotation. Explain why six-year cycles for crop rotation are better than four-year cycles.

▼ Fig. 104

Six-year crop rotation cycles

It is wise to stick to a six-year plan. The advantage of this is that it greatly reduces the risk of certain diseases. Four-year rotation cycles are often just a bit too short. The right order for growing the different crops is given schematically below.

year 1:

root crops
(carrot, onion)

year 4:

nightshade family crops
(potato, tomato)

year 2:

fruit crops
(cucumber, courgette)

year 5:

leguminous crops
(peas, broad beans)

year 3:

leaf crops
(lettuce, spinach)

year 6:

cruciferous crops
(cabbage, radish, rocket)

- 5 Why is it important in the crop rotation schedule to vary not only the species from year to year, but also the groups of crops, such as a fruit crop in one year and a leaf crop in the next?

EXTRA OBJECTIVE 12

Answer the following multiple choice questions.

1 Features of biocides include:

- 1 they work very quickly;
- 2 they are non-selective;
- 3 they can accumulate in the food chain.

Which of these features are advantages of chemical pest control in the case of an insect plague?

- A** Only feature 1.
- B** Only features 1 and 2.
- C** Only features 2 and 3.
- D** Features 1, 2 and 3.

- 2** Nun moths are a species of moth that can be found in forests in the Netherlands (see figure 105). Nun moth larvae only eat the needles of trees. Sometimes the plague is so bad that the trees are stripped bare. The plague can be tackled by releasing parasitic wasps in the forest. The parasitic wasps lay eggs in the nun moth larvae. The parasitic wasp larvae hatch from these eggs and eat the nun moth larvae from the inside. Is this an example of biological or chemical pest control? Will the number of parasitic wasps decrease or increase in the first few weeks?

Method

*Number of
parasitic wasps
will*

- | | |
|----------------------------------|-----------|
| A biological pest control | decrease. |
| B biological pest control | increase. |
| C chemical pest control | decrease. |
| D chemical pest control | increase. |

▼ Fig. 105



- 3** A certain food crop is damaged by a fungus. As a result, it yields less food. A chemical pesticide is used for tackling the fungus. After a few years, the fungus has become resistant.

Two pupils are talking about this.

Ishmael says resistance means that the food crop is not sensitive to the chemical pesticide.

Paula says resistance means that the fungus is insensitive to the chemical pesticide.

Who is right?

- A** Neither of them is right.
- B** Only Ishmael is right.
- C** Only Paula is right.
- D** Both of them are right.

- 4** In a certain area, potato plants were suffering from a plague of Colorado beetles (see figure 106). A chemical pesticide was used for tackling the beetles. This pesticide cannot be broken down by organisms.

A biologist compared 100 grams of biomass from the potato plants, Colorado beetles, insectivorous birds and birds of prey.

In which of these organisms will she find the largest quantity of this pesticide?

- A** The potato plants.
- B** The Colorado beetles.
- C** The insectivorous birds.
- D** The birds of prey.

▼ Fig. 106



Use figure 107 for questions 5 and 6.

- 5 Using the fungus to fight the rhinoceros beetles is a form of pest control. Two students are talking about this.

Wendy says, "This isn't biological pest control, because only the larvae are killed, not the beetles themselves."

Monica says, "This isn't biological pest control because a fungus is being used."

Who is right?

- A Neither of them is right.
- B Only Monica is right.
- C Only Wendy is right.
- D Both of them are right.

▼ Fig. 107

Rhinoceros beetles in palm trees

Rhinoceros beetles see coconuts as breakfast, lunch, dinner, a roof over the head and a nursery for their larvae all at the same time. The beetles are a pest for coconut growers. Rhinoceros beetles are roughly 10 cm long and they have a typical hard horn. They can have offspring four to five times a month. Within just a few weeks, the beetles can destroy the yield of a whole coconut plantation.

Researchers have discovered a fungus that can fight a plague like this. The fungus affects the beetle larvae. A large proportion of the larvae affected by the fungus die within thirteen days. But the plantation does then need to be treated with the fungus every year to restrict the damage done by the beetles. Tackling beetles using the fungus has one great advantage: it does not pollute the environment.



- 6 Which statement is about fighting plagues on a coconut plantation?
- A Rhinoceros beetles are used as a method of biological pest control in palm trees.
 - B Chemical pesticides are always used to protect palm trees.
 - C Using a fungus for protecting palm trees is a method of biological pest control.
 - D Using a fungus for protecting palm trees is a method of chemical pest control.

EXTRA OBJECTIVE 13

Answer the following questions.

- 1 Tony says that grey water comes from washing machines and other such appliances. Carol says that grey water comes from the shower. Who is right?
- 2 What environmentally polluting substances are often found in wastewater from agriculture and horticulture?
- 3 Write down two important causes of soil pollution.
- 4 What is meant by biological soil remediation?
- 5 In angling or sport fishing, small lead beads are often used to weight the fishing line. It is not unusual for these lead balls to end up in the water and stay there. Lead can dissolve in water. Pike, sticklebacks and water fleas live in a stream that is popular with fishermen. In which organisms will the highest concentrations of lead be found? Explain your answer.

You can do the extension if you have time left over. You can choose between different topics. This unit’s extension consists of three topics. You should do the exercises in your workbook.

1 Litter

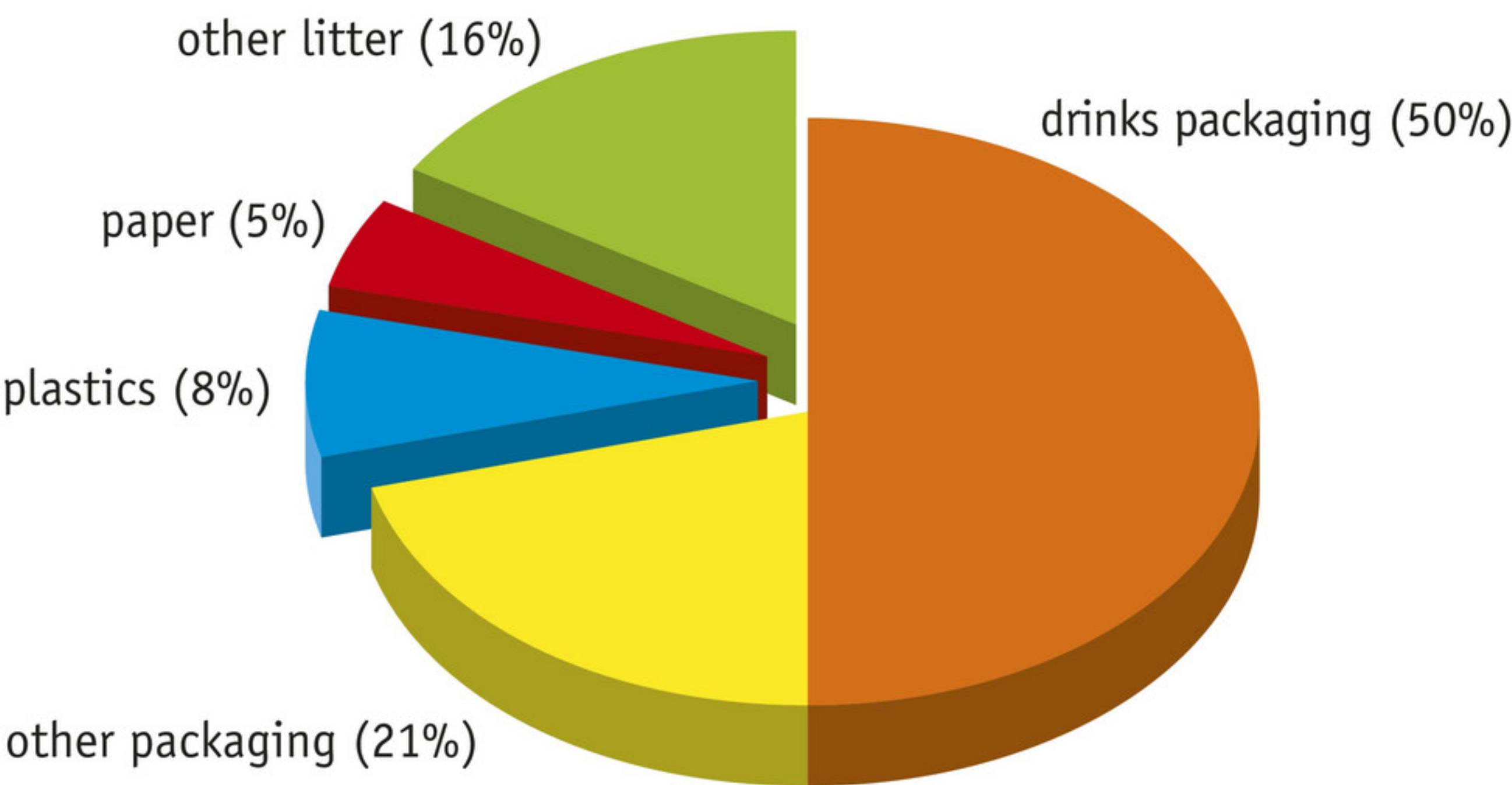
Waste that is just thrown away outside is called **litter**. In and around your school there will be litter as well. Sometimes a bit more, sometimes a bit less. The Dutch foundation ‘Nederland Schoon’ has developed a measuring method for litter. You can give a score saying how much litter is spoiling the area. In this extension, you are going to give marks for how much litter there is in and around your school. You work in pairs during this extension.

Litter can be drinks cans, empty bottles, newspapers, cigarette butts, used chewing gum, banana skins and so forth (see figure 108). Figure 109 shows the average composition of litter in the Netherlands.

► Fig. 108 Litter.



► Fig. 109 The volume of litter in the Netherlands.



Many people get annoyed by all the rubbish in the streets. But that does not stop us from leaving a right mess wherever we go (see figure 110). Studies have shown that people mostly drop litter out of pure laziness (see figure 111). Many people just cannot be bothered to keep hold of a piece of paper or an empty can for a little while, so they just drop it. Anyway, there is so much litter already, so what difference does it make? The funny thing is that a lot of people think there should be high fines for littering (see figure 112).

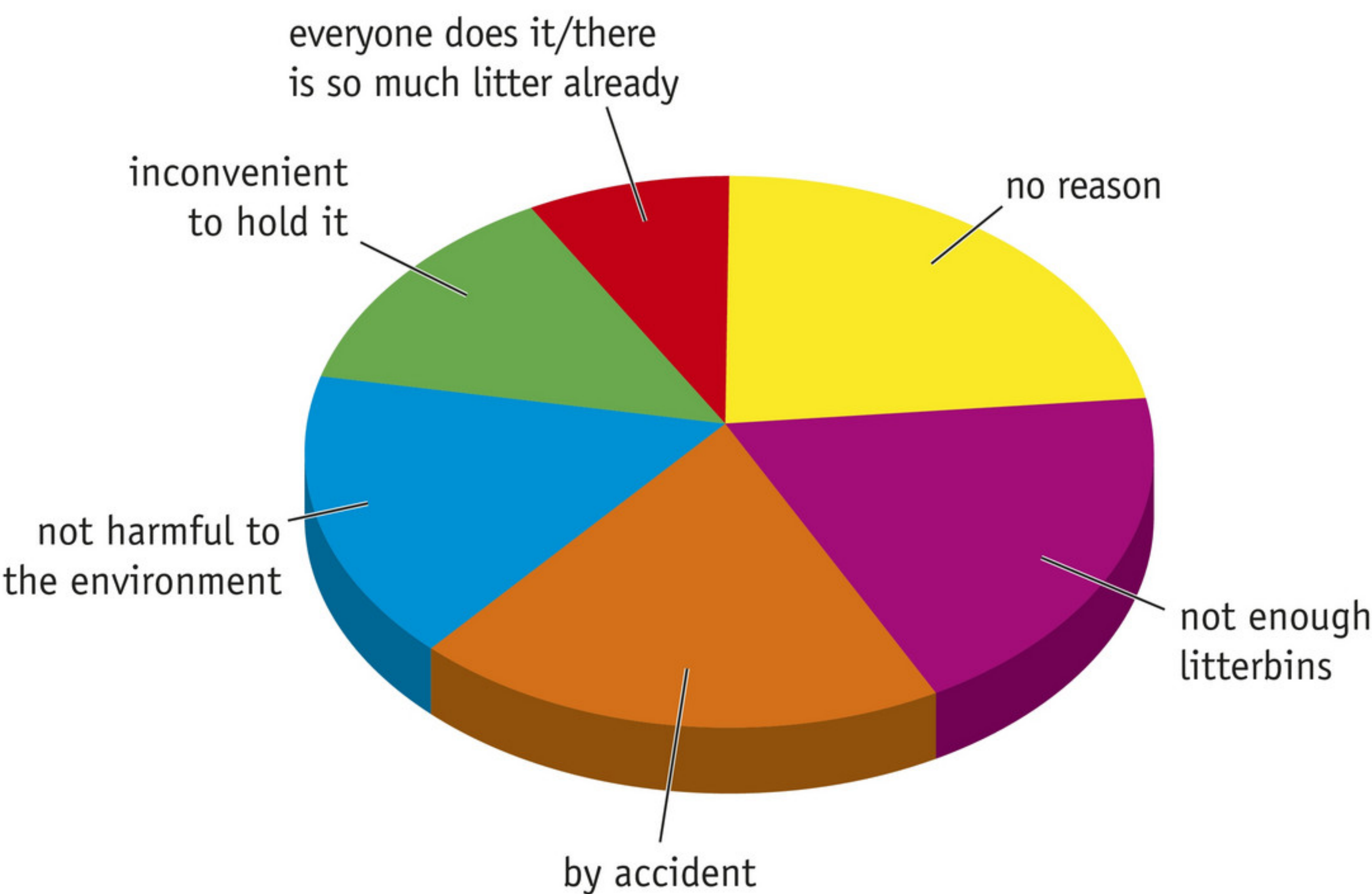
▼ Fig. 110

Rubbish in the streets

THE HAGUE – Two out of three people get extremely annoyed by the waste in the surroundings they live in. Dog mess tops the list of annoyances; litter is the second greatest source of irritation. But figures show that many people are litterers themselves. In 2014, after King’s Day in Amsterdam, more than 5500 rubbish bags

full of litter were collected by the local refuse collection service. Rijkswaterstaat (the Department of Waterways and Public Works) collects about 25 million kilograms of litter along motorways every year. An estimated 100 million kilograms of litter is collected from roads outside built-up areas.

▼ Fig. 111 Reasons why people drop litter.



▼ Fig. 112

The polluter should pay

Dutch people want high fines that will put a stop to littering. This is one of the most remarkable conclusions of a recent study conducted on behalf of the foundation ‘Nederland Schoon’. No less than 77% of the respondents think that littering could be discouraged by higher fines. Nearly half of the respondents think that a fine of €75 for littering would be perfectly

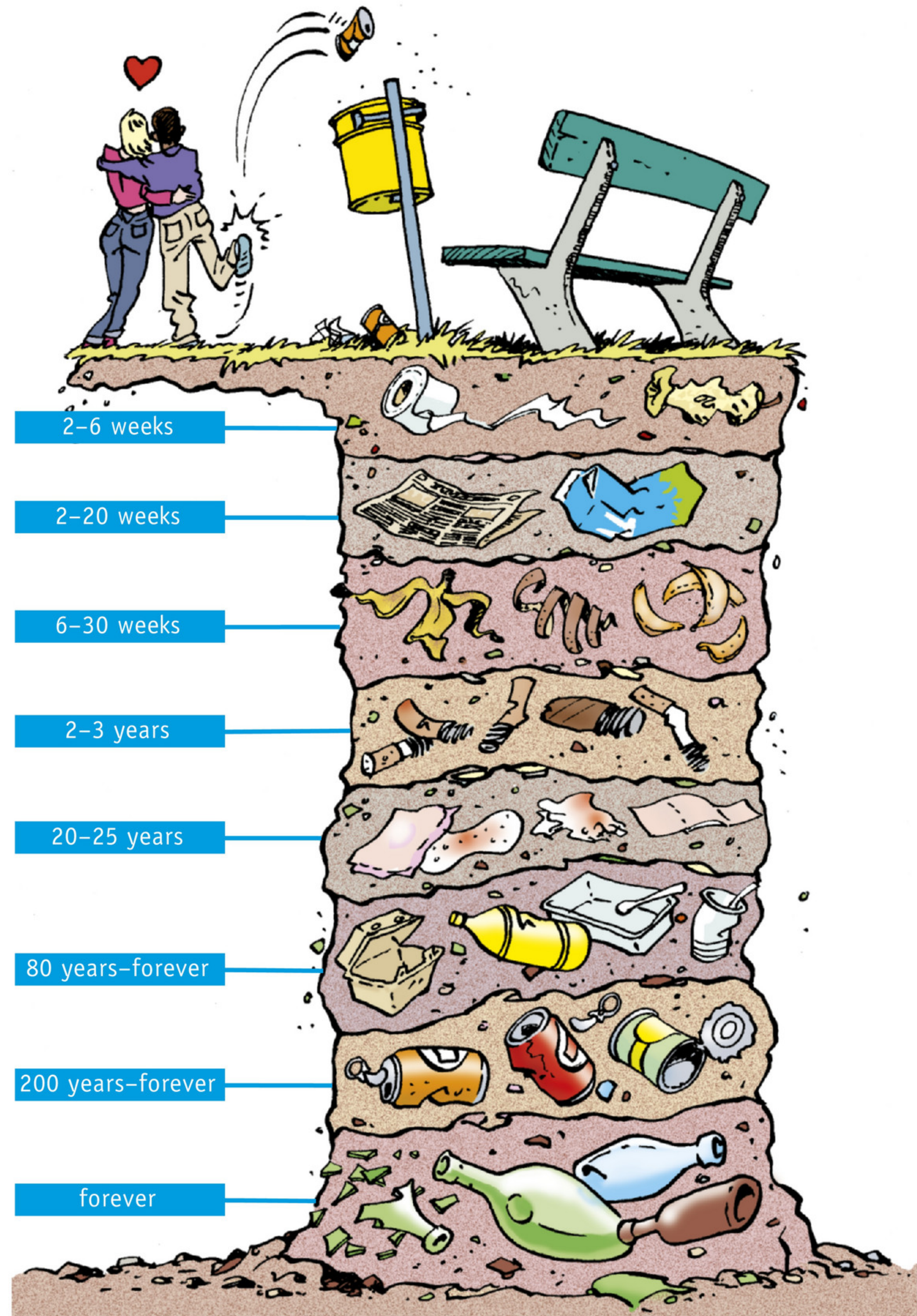
acceptable. Having more litterbins in public areas is the second most popular method for preventing litter. The third solution suggested by the respondents is that people should be better informed. For that reason, ‘Nederland Schoon’ has started a large-scale public awareness campaign.



A lack of knowledge is another reason for littering. Many people think that fruit skins, cigarette butts and used chewing gum do not harm the environment. After all, these products are biodegradable. But they do not realise that it can often take years before these products are broken down (see figure 113).

WB EXERCISE 1, PAGE 114

► **Fig. 113** How long does it take for litter to degrade?



2 Measures for protecting the environment

Most people in the Netherlands are aware that we should not harm the environment. If we want to keep the Earth fit to live in, we need to be aware of the consequences of our actions for nature and for the future.

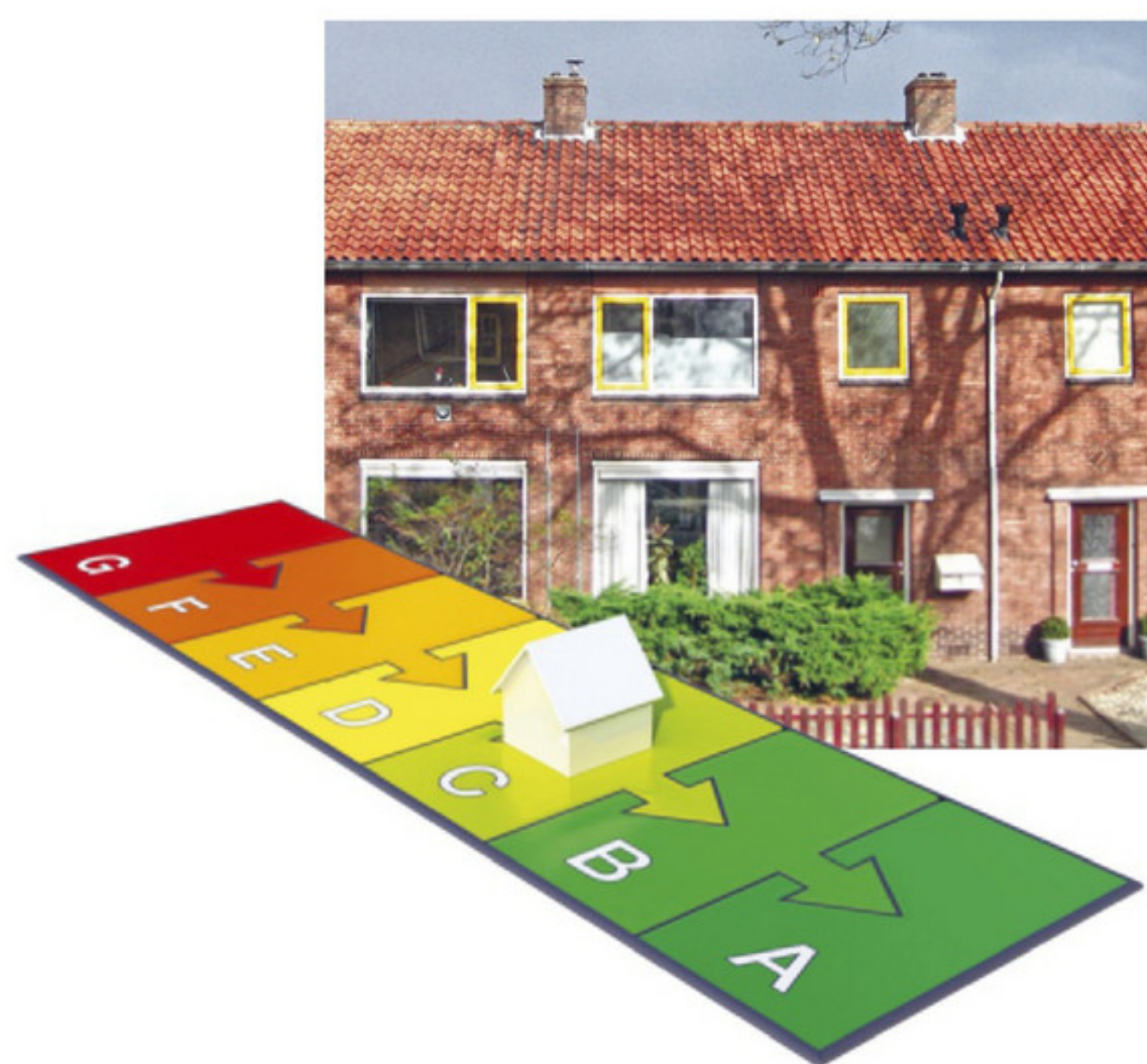
SUSTAINABLE DEVELOPMENT

In basics 2 you learned what sustainable energy is. Sustainable energy is one aspect of **sustainable development**. According to the United Nations (UN) this is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” Sustainable development is related to everything that people do. As well as sustainable energy, there is sustainable agriculture, sustainable housing and sustainable business practices. All these forms of sustainable development try to respect the environment as much as possible.

GOVERNMENTAL MEASURES

The countries of the European Union collectively make rules that people, industry and agriculture have to respect. For example, for many substances, the maximum concentrations allowed in the air have been determined. The idea is that this will improve air quality. Basics 4 mentioned a few measures to stop acidification of the environment: cars have been given catalytic converters and factories have placed filters in their chimneys. If the amount of carbon dioxide released into the air is to be reduced, it is important that less energy is used. Measures that help include insulating houses and using energy-efficient appliances. Energy labels tell you how energy-efficient a house, device or car is (see figure 114).

► Fig. 114



1 energy label for a house



2 energy label for a car

By giving us this kind of information, the government wants to encourage us to waste less energy (see figure 115). After all, 26% of the energy consumption in the Netherlands is used by houses and the people living in them (see figure 116).

▼ Fig. 115 Being energy-conscious.

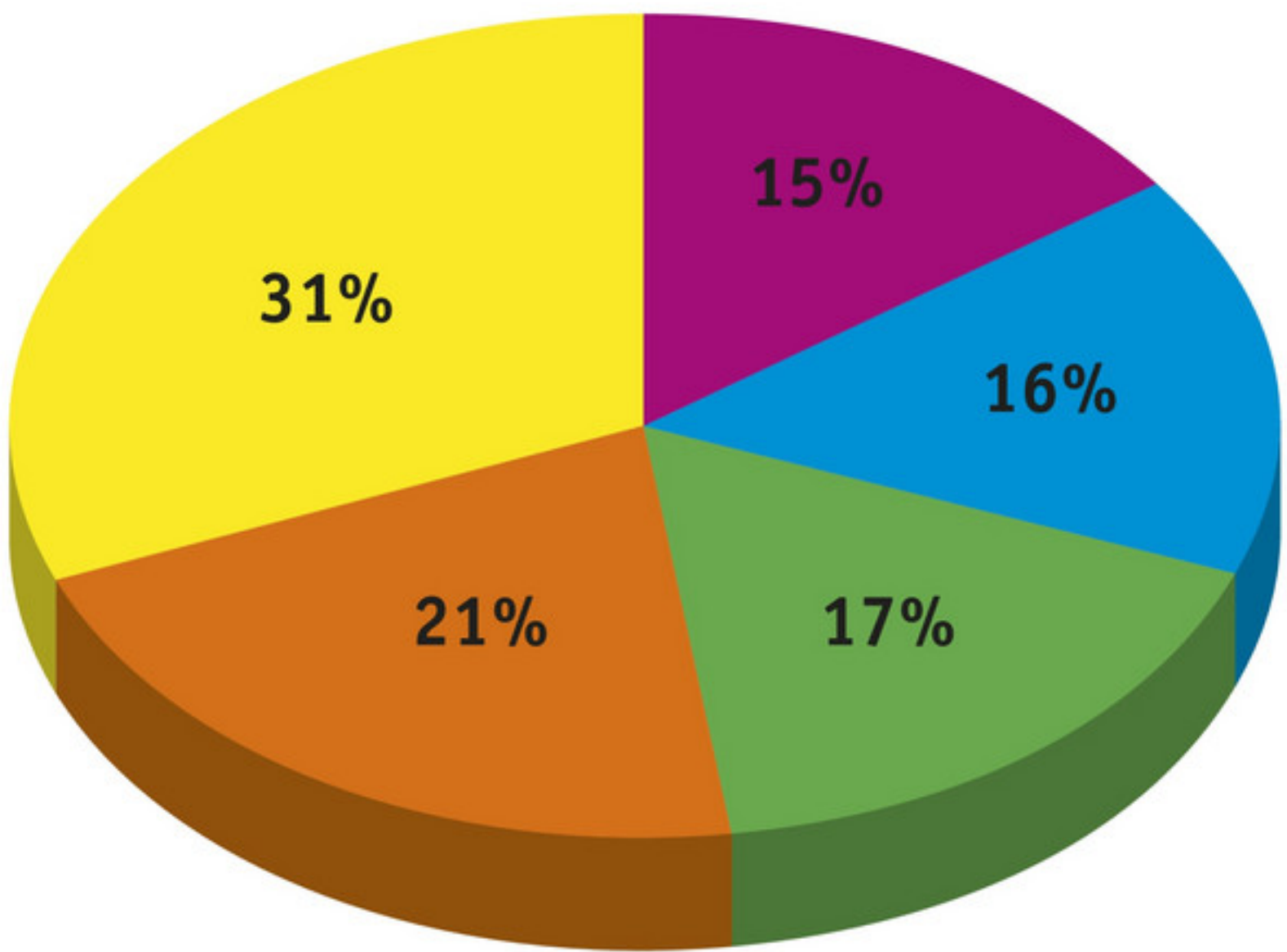


1 some people use their car whenever they go anywhere



2 other people take their bike or travel by public transport

► Fig. 116 Energy consumption by households.



- Legend:
- heating water
 - lighting
 - cooling
 - washing and drying
 - various electrical appliances

URBAN FARMING

Researchers have calculated that there will be roughly nine billion people in the world by 2050. Twice as much food will have to be produced in order to feed all these people. There is currently not enough agricultural and horticultural land for producing this large amount of food. The possibilities for urban farming are now being studied, as a way of preventing more nature areas being destroyed to create agricultural and horticultural land. Urban farming means growing, processing and selling or distributing food in an urban environment. Urban farming is often done on buildings or on roofs.

▼ **Fig. 117** Vertical farming in Singapore.



One special form of urban farming is vertical farming. Vertical farming involves stacking crops in a building within an urban environment. When several crops are grown above one another, much less agricultural land is needed. And as the food is produced in the city, it can immediately be sold in the same city as well (see figure 117).

HOW ENVIRONMENTALLY AWARE ARE YOU?

What do you do to cut your energy consumption? For example, do you switch off the light when you leave your room? Or do you ever buy things in second-hand shops (see figure 118)?

WB EXERCISES 1 AND 2, PAGE 116

► **Fig. 118**



3 Preparing a soil profile

▼ **Fig. 119** A soil profile.



The ground that you stand on has a lot of different layers. Each layer has its own features which are an important factor determining what plants will grow there. The amounts of nutrients, water and oxygen are important properties, for example, that affect the growth of plants. In other words, the vegetation of any given area is partly determined by the soil. The workbook tells you how to prepare a soil profile.

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